Electrochemical Industry

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ADVERTISING RATES GIVEN ON APPLICATION.

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THE BRADLEY PATENT DECISION.

On another page of this issue, we publish in abstract the decision rendered by the United States Circuit Court of Appeals in the case of the Electric Smelting & Aluminum Co., as complainant-appellant, versus the Pittsburg Reduction Co., as defendant-appellee. This decision is the outcome of a suit which is part of an extended litigation which has been going on for many years. In this litigation two patents have become famous; the Hall patent, relating to the use of alumina dissolved in a double fluoride bath as electrolyte, and the Bradley patent, referring to the internal heating of the bath by means of the electric current. There have been three different suits. One (in which the Pittsburg Reduction Co. was not involved) concerned merely the ownership of the Bradley patent; this suit was decided in 1897 in favor of the Electric Smelting and Aluminum Co. (successor to the Cowles Electric Smelting and Aluminium Co.). The other two suits were between the Pittsburg Reduction Co. and the Cowles Electric Smelting and Aluminium Co. concerning alleged infringements of the Bradley patent and the Hall patent respectively. By a decision of Judge Taft, rendered in 1893, in a suit of the Pittsburg Reduction Co. versus the Cowles Electric Smelting and Aluminium Co. the latter company was declared to be an infringer of the Hall patent. By a decision rendered by Judge Wing in April of this year, this case was reopened for the introduction of new testimony and reargument on its merits. This case is still pending. Besides this case there has been pending a suit of the Electric Smelting and Aluminum Co. versus the Pittsburg Reduction Co., wherein the former company has been suing the latter for infringement of the Bradley patent. This case has now been decided by the Court of Appeals in favor of the Electric Smelting and Aluminum Co. and the Bradley patent has been sustained. There is, of course, a remote possibility that this case may be taken up by the Supreme Court.

The manufacture of aluminium on a commercial scale, according to the present state of the art, involves both the use of alumina dissolved in a double fluoride bath as electrolyte, and the utilization of the heat produced by the current in the bath. The use of the electrolyte is covered by the Hall patent, which is owned by the Pittsburg Reduction Co. The use of the internal heating by means of the current is, according to the recent decision of the court, covered by the Bradley patent, which is owned by the Electric Smelting and Aluminum Co. Should the legal situation remain unchanged, the commercial manufacture of aluminium depends upon these two patents, owned by the two different companies, and it will be impossible for anybody in the United States to make aluminium commercially, except under license from both the Pittsburg Reduction Co. and the Electric Smelting and Aluminum Co.

For one special reason the recent decision appears to be of great general importance. While the Hall patent will run out in 1906, the Bradley patent will run until 1909, so that the present method for making aluminium electrolytically will be covered by patents three years longer than had the Bradley patent not been sustained.

ALUMINOTHERMICS.

We need offer no apology for publishing the elaborate and exhaustive article of Dr. Hans Goldschmidt on aluminothermics, although the subject is not strictly electrochemical. The principle common to all the different practical applications of aluminothermics lies in the facts that the oxidation heat of aluminium has a very high value, and that the combination of aluminium with oxygen proceeds with a very high velocity. These facts have been known for quite a while, but the development of the methods by which this thermochemical reaction was made a certain and controllable one, applicable to very different engineering purposes, is to be placed to the credit of Dr. Goldschmidt. The article published in this issue gives the most complete and up-to-date information published so far on this subject, and this information is authoritative, because it comes from the inventor himself.

The subject of aluminothermics is of special interest to electrochemists, because aluminium, as made commercially at present, is an electrochemical product. This is not incidental, but is to be considered as a special case of the general principle that by electrochemical methods we are enabled to produce that class of chemicals in which a great amount of energy is stored up. In fact, electrochemical methods are the most effective ones known at present for storing energy. We have to expend a certain amount of energy to make aluminium electrolytically, and of this we thus store in the aluminium an amount which it is able to give off later by combining with oxygen. The time and the place at which it is made to give off its energy is absolutely under control of the experimenter. The case of calcium carbide is quite analogous. In manufacturing calcium carbide in the electric furnace, we store in the calcium carbide a certain amount of energy which at any time and any place can be recovered by bringing the carbide in contact with water, thereby generating acetylene. Aluminothermics is thus connected with electrochemistry, since in the aluminothermic reaction, we get back energy which we have previously stored up in making the aluminium electrochemically.

It would, however, be wrong to suppose that the high oxidation heat of aluminium explains fully the effectiveness of the aluminothermic reaction for engineering purposes. Silicon has also a high oxidation heat, but, as Dr. Goldschmidt shows, it cannot be used as a substitute for aluminium in the thermic reaction. The reason is that, besides heat of oxidation, the speed with which such a reaction proceeds is another factor which determines its applicability to engineering purposes. These cases clearly indicate the limitations of the energy principle, which states nothing more nor less than that in all processes in nature the sum of all forms of energy in any distinct system of bodies remains unchanged as long as this system does not receive energy from, or give energy to, the outside. In the light of the energy principle alone, the conditions at the beginning and at the end of a reaction are equivalent, the energy being the same in both cases. If we want to know whether a reaction will go on in a certain direction or in the opposite direction, we cannot get an answer from the energy principle. True, we know that in chemistry Berthelot's rule, that the reaction goes on in such direction that heat is developed, is very often correct; but Berthelot's rule is not always true, and cannot be considered of the same importance and scope as the energy principle. From a scientific point of view it is much safer to adhere strictly to the fact that the energy principle has nothing to do whatever with the direction in which a reaction goes on. To determine this, we have the second principle of thermodynamics which says that the reaction goes on in such a direction that the entropy increases. This principle, however, gives us the direction, but not the speed with which the reaction goes on; and the negative results of the attempt to substitute silicon for aluminium in Goldschmidt's thermic reaction indicate conclusively that the speed of reaction is a factor of the greatest importance. Concerning the speed of reaction we have not yet a general principle, and have to make in each case experiments to determine the speed for that case.

The article of Dr. Goldschmidt should be of special interest to those of our readers who are connnected with the iron and steel industries. A few years ago iron and steel men were in no way interested in electrochemistry. In the meanwhile numerous attempts have been made to apply electric furnace methods to this field, as is known to our readers from numerous articles on this subject published in this journal. But these electric furnace methods do not exhaust the connection of the iron and steel industries with electrochemistry, as is shown by the extended use to which the aluminothermic reaction may be put, not only for welding and repairing purposes, but also for improving steel castings. This illustrates the development which is steadily going on, and by which electrochemical methods are entering fields which were formerly believed to be absolutely outside of electrochemistry.

CLASSIFICATION OF ELECTROCHEMISTRY.

In our present issue we publish the conclusion of Mr. C. P. Townsend's "Notes on the Classification of Electrochemistry." In reading this paper, one is astonished how large a field is really covered by this young art and science. Not long ago electrochemistry was considered a rather special branch of chemistry or of electrical engineering, and the number of those interested in this special field was rather small. But the situation has completely changed, as is indicated by the steadily growing interest among all classes of engineers and scientists in matters electrochemical. This is not surprising, in view of the fact that electrochemical methods are being tried or introduced in fields which had formerly been considered entirely outside of electrochemistry. Under these circumstances, a classification of all the various branches of electrochemistry is a timely subject for discussion.

Mr. Townsend's paper is neither a summary of the present condition of the several branches of electrochemical industry,

nor is it a resumé of progress. It purports to be merely an outline of a convenient and elastic classification of the subject matter of the art, with sufficient of comment upon the scope of the sub-divisions to indicate the character of the material included therein. The utility of the outline lies in its applicability to the classification or indexing of notes for reference. This is becoming daily a matter of greater perplexity and importance for everybody who wants to keep a convenient record of the progress of the art.

Mr. Townsend's scheme of classification has recently been adopted unofficially by the Patent Office, and is now the working system by which the United States and foreign patents are classified in the examining division. It was primarily designed for this work, the essential condition of which is that the examiner shall have on hand for ready reference an index to notes which will guide him to the patent and other literature bearing upon the subject matter of any application which may be filed. In the case of patents these are, of course, themselves the notes and are filed under the indicated heads. The above condition is a very difficult one to fulfill in practice, but to a lesser extent it represents the need of every worker in the field.

LOCAL SECTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

From a note on another page of this issue it will be seen that the establishment of local sections of the American Electrochemical Society at Madison, Wis., and at New York City is now well under way. The Electrochemical Society thus follows the example set by the American Institute of Electrical Engineers, which has found that this plan has had a beneficial effect in increasing membership. A similar result may be hoped for in the new departure of the Electrochemical Society, but in its case local branch organizations in the larger cities could fulfill a still more important mission. The most important broad result of the foundation of the national Electrochemical Society is probably the fact that it has firmly bound together in professional solidarity the numerous workers in the art and science of electrochemistry in this country. Much remains, however, still to be done in this direction, and it seems that in this respect local sections could accomplish very much. If meetings of the local sections are not loaded with elaborate papers, but are more devoted to a general and informal discussion of engineering questions which come up in the practice of every worker in the field, they would attract undoubtedly large audiences of electrochemists, chemists, metallurgists, electrical and mining engineers, and many would participate in the discussion and probably impart some valuable information, who would refrain from doing so in a more formal session. It is the rank and file of the Society which should be induced at meetings of the local sections to speak of their observations and of their troubles. Electrochemical methods are entering so many fields that it becomes difficult for any one to be fully conversant with the whole art. To counteract this disadvantage, there seems nothing better than local section meetings in which chemists, metallurgists and electrical engineers may exchange thoughts and information on subjects which concern all of them.

ELECTROCHEMICAL NOTATION.

In this issue we publish the table of electrochemical notation proposed by Prof. Nernst, as chairman of a special committee of the German Bunsen Society and adopted by the Electrochemical Section of the Berlin International Congress for Applied Chemistry. That this table is not to be considered as definitive, is, however, indicated by the fact that a motion of Dr. Noyes, to appoint an international committee of five which shall make a report to the next Congress, was adopted in general meeting. The table of the Bunsen Society is, therefore, to be considered rather as a proposal, open for general discussion. It seems worth while to call attention to the fact that an international agreement on electrochemical units and notation should not be reached by a congress of chemists alone, but in co-operation with an international congress of electrical engineers. It would be very desirable if the St. Louis Electrical Congress of next year would take up the matter and state its position clearly, so that at the next Congress for Applied Chemistry, which will be held in Rome in 1906, the position which electrical engineers take toward the proposal will be clear. It is probable that some notations given in the German table will never find acceptance in this country, for instance, W for resistance. The expression "conductance in reciprocal ohms per centimeter cube" is incorrect and should read conductivity instead of conductance. A question which arises, is whether it is wise to include in a table of notation numercal data for constants of nature. Concerning notation a general agreement can be reached which shall then be adhered to. On the other hand, the figures for constants of nature are always more or less uncertain, and every new extended experimental investigation is liable to change them. For instance, in the table the charge of the univalent gram ion is given as 96,540 couloumbs. This is the old well-known value which is in very extended use. From more recent investigations it seems, however, probable that 96,600 is nearer the truth than 96,540. In the same way the figures for all constants of nature are liable to be changed. Nevertheless uniformity in using these figures has great advantages, so that it might be considered preferable to give the numerical figures in the table of notation and to issue a new edition of the table whenever necessity arrives.

While international congresses are undoubtedly the only proper places for issuing such tables, we like to emphasize that a thorough discussion of the matter in the columns of the technical and scientific press would be in order before a congress meets. In order to produce a table which will be generally adopted in practice, all the various workers in the field should have a right to make suggestions. Such a table shall be used by the rank and file of the science and art, and they must be heard before the table is adopted. An international congress, however, is not the place for such a thorough discussion. It should adopt what has been found to be the best in a thorough previous discussion. As this matter is of great practical importance, we would like to open our correspondence columns to a discussion of this question. Formulas are like a method of stenography for expressing concisely scientific and technical thought, and a uniform notation would render the understanding of formulas easy and would avoid much confusion.

THE BRADLEY PATENT DECISION.

The United States Circuit Court of Appeals has just handed down the decision in the suit between the Electric Smelting & Aluminum Co. as complainant-appellant versus the Pittsburg Reduction Co. as defendant-appellee. The case was argued before Judges Wallace, Lacombe and Coxe, the appeal being from a decree of the Circuit Court for the Western District of New York, dismissing bill filed by the complainant for the infringement of two letters patent granted to C. S. Bradley, the patent in controversy on this appeal being No. 468,148, dated February 2, 1892.

After giving the subject matter of the Bradley internal heating patent and quoting some of its claims, the decision continues:

"The Circuit Court found that the claims were not infringed and dismissed the bill. The complainant assigns error, contending that the court erred in placing a narrow construction upon the claims and in holding that the defendant's process did not infringe. The complainant also contends that the court erred in holding that the success of defendant's process was due to the invention of Hall and not to Bradley * * *

"The defendant is engaged in producing aluminium. The investigation may, therefore, be confined to this one metal, for if the patent, when so limited, be valid and if the claims cover the defendant's process it matters not what else they cover or fail to cover. We start, then, with the undisputed fact that prior to Bradley's invention no one had ever succeeded in separating aluminium from its compounds solely by the use of electricity, or, in other words, no one had dispensed with external heat."

As to the reference principally relied on to anticipate or limit the claims of the Bradley patent, the court refers to the well-known experiment of Sir Humphrey Davy made in 1807, and concludes that "the fact that Davy's experiments were permitted to lie dormant during seventy-six years of intense activity in chemistry, electricity and metallurgy, is almost conclusive evidence that the complainant has overestimated its importance." Some other references are then briefly discussed and the decision continues, as follows:

"The principal expert for the defendant, Dr. Chandler, whose reputation for learning and ability is well known to the courts, although of the opinion that slight modifications of the previous methods would produce the Bradley process, nevertheless admits frankly 'I do not recall any one process which, when applied to the ore aluminium, would without any modification whatever have produced aluminium, in which process both the fusion and the electrolysis would have been accomplished by the electric current.' Not only did the electricians of the earlier art fail to produce aluminium by electricity alone, but the wrecks which strew the pathway which Davy pointed out nearly a century ago, offer mute but impressive proof of the genius of the man who first surmounted its many obstacles and reached the destination in safety. * * * The effort of inventors was directed to the perfection of processes in which external heat was employed to melt the ore and keep it in a fused state. The record abounds in such instances. * * * Many of these inventions were long after the introduction of dynamos and they continued to be made and practiced for several years after the Bradley invention. Indeed, so strongly was the inventive trend toward the employment of external heat that even the defendant's inventor, Hall, could not be induced to dispense with its use until 1889. When the defendant's works were started at Pittsburg, in December, 1888, the pots were built to be externally heated, and they were so heated for some time thereafter. * * * *

"Since the Bradley invention aluminium, which formerly was regarded as one of the precious metals, has become as common as copper and brass and its price has been reduced from $15 per pound to 25 cents per pound. We do not intend to intimate that this marvelous change was due solely to Bradley's invention, but simply, at this time, to emphasize the fact that it took place after Bradley's invention. If he has done nothing to produce this result he is, of course, entitled to no consideration whatever, but if he has contributed something, he is entitled to protection to the extent of that contribution, be it much or little.

"We have proceeded thus far to the conclusion that we are dealing with a patent which discloses a meritorious process for producing aluminium in large quantities, the essential features of which are, first dispensing with external heat, and, second, the use of the same electric current to produce and maintain fusion and electrolize the ores of aluminium. We are unable to discover anything in the prior art describing this process or anything closely approximating thereto. The patent is, therefore, not anticipated and its claims are entitled to a liberal construction.

"The judge of the Circuit Court, after careful and painstaking research, reached the conclusion that Bradley had made a valuable invention, but he failed to grant relief to the complainant upon the theory that the process which the defendant uses was an entirely separate invention, neither dependent upon nor subsidiary to the invention of Bradley. In this we think there was error. Hall's achievement should be considered in the light of an improvement upon Bradley's fundamental discovery.

"There can be little doubt that the defendant's process is a valuable one, and that to it is largely due the cheap aluminium of the present day. There is not the least disposition to detract from the merits of Hall or minimize his contribution to the art. Indeed, it may be conceded that, if the novel features so introduced be secured by a valid patent, he can hold the monopoly against all, Bradley included. This concession does not permit him, however, to appropriate the broad invention. He does not acquire the right to use the Bradley process simply because he has improved that process. He is entitled to enjoy what is his, but in doing so he cannot appropriate the property of another. The record discloses nothing unusual in this regard. It is rarely that an invention develops ultimate perfection in the hands of the inventor. The test of actual use discovers defects to be remedied and suggests improvements to be made. If the inventor produces a new and useful result he does not lose his reward, because he, or someone else, subsequently renders it more useful."

The court compares the process as operated by the Pittsburg Reduction Co., with the process described in the Bradley patent, and says: "That differences exist cannot be denied; that they are material is strenuously denied. * * * Speaking generally, it is thought that most of the points of variance relied on can be traced directly to the improvement introduced by Hall, namely, the use of cryolite as a solvent for alumina. Were it not for this change it is hardly probable that infringement would be denied. But the change of materials does not create a new process, but a new way of working the old process.

"The complainant's position regarding the Hall process, as used by the defendant, is sententiously stated in one of the briefs as follows: 'We contend that the process actually practiced by defendants is that of Hall *minus* the impracticable external heating feature shown by Hall, and *plus* the desirable and eminently successful internal heating feature of Bradley.'"

The conclusion of the decision reads as follows:

"Although the appeal included both patents the argument has been confined wholly to No. 468,148. It follows that the decree, in so far as it relates to letters patent No. 464,933, must be affirmed with the costs of this appeal, and in so far as it relates to No. 468,148 the decree is reversed with the costs of this apppeal and the cause is remanded to the circuit court with instructions to enter a decree in favor of the complainant for an injunction and an accounting, with costs."

The opinion rendered was written by Judge Coxe and concurred in by Judges Wallace and Lacombe. We comment on it on another page.

ON THE MANUFACTURE OF FERRO-ALLOYS IN GENERAL AND OF FERRO-TITANIUM IN PARTICULAR IN THE ELECTRIC FURNACE.

By AUGUSTE J. ROSSI.

The manufacture of special steels has always attracted much interest, and in view of meeting the constantly increasing demand for a metal stronger than the ordinary carbon steel, or one possessing special properties better adapted to specific uses, metallurgists have studied the influence of metals, other than iron, which, introduced in the steel, might communicate to it the qualities required in each case.

What we say of steel may also well be applied to cast-iron itself. With the development of the railroads, of their equipment, cast-iron of a greater strength than the one that had been used before has become a necessity as material for wheels which have to stand now nearly double the maximum load permitted a few years ago. More attention has been given to mixtures, and even some manufacturers have thought of introducing in the cast-iron also, another metal which could increase its resistance. In this line of idea nickel has been resorted to, and now other metals or their ferroes are experimented with for car wheels and rails.

A metal can be introduced in iron in two forms, either as metal or as ferro, that is, an alloy of iron with one or more of the other metals. But, owing to the cost of the manufacture of the metal itself, which is generally more expensive than that of its ferro, this latter form has been most often resorted to.

To secure this increase of strength, however desirable it may be, the cost of the metal or ferro added must not be such as to become exclusive or limit its use to a few special applications. Unfortunately of the metals, other than iron, that can be used, many are of a comparatively rare occurrence in nature, met most generally associated with oxides of iron and often in too small quantities to be used in that state. It is thus that, while manganese ores are common enough, chrome and nickel ores are much less so, hence more expensive; and others, such as tungsten, molybdenum, vanadium, uranium ores are sparsely found, in small quantities and only in certain localities. This is not the case with titaniferous ores. There is hardly any iron ore in certain districts which does not contain a more or less important percentage of it, while in certain States of the Union, in the Adirondacks (N. Y.), for instance, in Canada, Sweden, Norway, Russia, and many other parts of the world, they are found in immense deposits, in mountain masses, associated with iron ores to the extent of from 5 to 40 or 50 per cent of titanic oxide and more. Titanic oxide itself, Rutile, is not only frequently found, but, in some newly discovered deposits in Virginia, it is claimed to have been met in a rock formation to such an extent as to render its use industrially and economically possible.

Titaniferous iron ores containing from 10 per cent to 50 per cent of titanic oxide can be as cheap and even cheaper than ordinary iron ores, so that, if the ferro-titanium, which can be manufactured from them, were to be conceded, after proper industrial and satisfactory tests to impart to iron valuable qualities, as valuable as those secured by other ferroes, it would prove also the most economical (excepting possibly ferro-manganese) for industrial applications.

The metals mentioned above occur in nature sometimes as sulphides (molybdenite, nickel pyrrothite), sometimes in combination with lime and manganese (scheelite and wolframite for tungsten), or in some other form, but most generally and abundantly also as oxides associated with oxides of iron, and very often a concentration is necessary to free them from the non-metallic gangue in which they occur. The concentrates are then the first materials for the production of the ferroes.

The reduction of some of these metallic oxides can be secured by carbon in the blast furnace (ferro-manganese, ferro-silicon and ferro-chrome even up to certain percentages), but, for others, the heat of the electric furnace is necessary and, even for the first named, the development of electrical engineering and the establishment of electrical power plants with favorable conditions of cost has rendered their electrical smelting more economical than the blast furnace method. This even has been the case for iron oxide itself, so that iron and steel, under favorable conditions of location, cost of ores and current, can be made in the electric furnace as cheap as in the blast furnace as it is claimed by some. We refer the readers to the several articles on this subject which have appeared in these columns on the electrical smelting of iron.

In all that follows we do not intend to treat of the reduction of the metals, other than iron, by electrolysis in the wet way or by igneous fusion, but of their electrical *smelting*, as the word is *commonly understood*, and the reduction of their oxides as such or associated with oxides of iron, by methods which apply equally as well to all of them or their ferroes, let them be ferro-manganese, ferro-nickel, ferro-silicon, ferro-chrome, ferro-tungsten, ferro-molybdenum, ferro-vandium, ferro-uranium, ferro-titanium.

As regards ferro-silicon, we include it in th elist, though silicon is not a metal. But though ferro-silicon up to 12 per cent silicon or thereabout can be manufactured in the blast furnace, yet above this figure the electrical treatment is the only economical and sure one. As to ferro-manganese, though manufactured currently in the blast furnace up to 80 to 82 per cent manganese, there are certain physical conditions of some of its ores which, in localities benefited by the facilities of obtaining both the ores and the current at very low rates, would render an electrical treatment advantageous.

As regards ferro-nickel and nickel, its manufacture by electrolysis or special metallurgical processes is too well known to be considered by us, but the methods of electric smelting to be described apply equally well to it, and may even, in certain special circumstances, prove preferable.

When these metallic oxides are reduced by carbon, the ferro metal contains an important amount of this element which may vary from 3 to 8 per cent or more, and though not objectionable for certain applications it is so for many others, for which an allowance of carbon less than 1 per cent is the only one admitted. Subsequent treatment of these high carbon ferroes with addition of lime or other substances in the electric furnace, may free them from a large part of their carbon, but besides the cost of such method it is next to impossible, in most cases, to reduce the carbon to the admissible limit. Metals or ferroes quite free from foreign elements can be prepared by special chemical and other processes, but it must be borne in mind that in what follows we speak of metals *industrially* possible *on a large scale*. In order to obtain these ferroes practically free from carbon, another reducing agent has to be resorted to.

The property of aluminium to reduce metallic oxides has been known as a curiosity of laboratories for the last fifty years or so. By mixing together aluminium in powder with the oxide to be reduced in the same powdered state and placing the mixture in a crucible strongly heated in a furnace, the metal of the oxide was reduced to the metallic state by aluminium, which oxidized to alumina at the expense of the oxygen of the metallic oxide, owing to the great heat of formation of alumina. This reaction is *exothermic*, that is, once started at a point of the mass, it can proceed without the intervention of any external heat. Consequently, in this mode of operating, the reaction was so violent as to project the whole mass from the crucible, becoming actually dangerous when experimenting on more than insignificant quantities of substances. It was due to Dr. Hans Goldschmidt to show how to control this reaction and to render it capable of industrial applications, not only in this line of reduction of oxides, but for producing locally and at once an intense heat available for different purposes, such, for instance, as soldering in

loco broken rails, or cracked steel castings, etc. In fact, this heat generating property of aluminium, as utilized by Dr. Goldschmidt, has formed the basis of a new branch of technology, the "aluminothermics," as it is called. We will only briefly record here such of its salient points as bear on our subject.

If a mixture of powdered aluminium and of powdered oxide charged cold in a proper vessel, is brought up, at one point of the mass, to the temperature necessary to produce the ignition of aluminium and start the reaction, the latter will proceed by contiguity of mass without the intervention of any external heat, until the reactions are completed. This starting is secured by a sort of fuse made of a mixture of aluminium and of an oxide readily yielding its oxygen (such as barium or sodium peroxide), both in powder or very fine grains, the finer the better. This fuse is primed in its turn by means of a ribbon of magnesium.

To illustrate the working of the method, let us apply it to the reduction of such a metallic oxide as ferric oxide F_2O_3. The equation $Al_2 + Fe_2O_3 = Al_2O_3 + Fe_2$ shows that 0.484 kg. of aluminium are required per kg. of metallic iron Fe.

I kg. of aluminium by its oxidation to Al_2O_3 disengages 7140 calories. To reduce 1 kg. of iron, metallurgy teaches us that 1796 calories are required, and about 360 calories additional to melt the iron reduced from Fe_2O_3. If we add to this the heat necessary to melt the alumina slag resulting from the oxidation of 0.484 kg. Al (or $0.90Al_2O_3$), at the rate of 600 calories or thereabout per kg. of Al_2O_3 melted, we come to a total of heat necessary for the reduction of 1 kg. of iron (from Fe_2O_3), of some 2700 calories. As 0.484 kg. aluminium can supply: $0.484 \times 7140 = 3456$ calories, we see that we have a surplus of some 756 calories for losses, etc.

As applied to the manufacture of ferroes, this method requires necessarily a certain manipulation. The mixture of the two powders must be made very intimate and, owing to the rapidity of the reaction, two or three minutes at most, some of the oxide may escape reduction and a certain part of aluminium remain in the ferro or metal obtained. It is not our intention to criticise this method, but merely to point out possibilities when carried on a continuous and large industrial scale. At any rate, we may be allowed to say that it requires special care in the manipulations.

The method we have proposed and applied is based also on the use of aluminium as a reducing agent, but, instead of using this metal in fine powder or grains, we carry the operation in an electric furnace, in a *bath of aluminium*. The aluminium in waffles, ingots, scrap or the like, is first charged in an electric furnace and the current started. It melts in very few minutes, and in this molten bath we shovel the metallic oxide or oxides as such as concentrate. The reaction sets in at once, aluminium oxidizes with incandescence, the furnace becomes glowing white, and we can then reduce considerably or stop entirely the current until the reactions are complete or have lost of their intensity, when we supply again the current for a few minutes more to keep in a molten state the ferroes or metals obtained which can then be freed from any aluminium they may contain, if any, by the addition of a small quantity of the original oxide used. The metal is then cast. Other injurious elements in the ferro could even be removed by appropriate addition before casting.

As applied to ferro-titanium, for instance, the method consists in charging in the bath of aluminium titaniferous iron ores, that is, titanic oxide associated with iron oxide. Iron is reduced first, forming a bath in which the titanium reduced by the aluminium in its turn dissolves, yielding the ferro-titanium. Were rutile to be used (titanic oxide, practically free from iron oxide), instead of titaniferous iron ores, and were a ferro-titanium of a certain percentage to be desired, after or before the aluminium, there is charged in the furnace the proper quantity of good scrap-iron, thus diminishing the expense in aluminium by all the quantity of this metal which would have been required to reduce a quantity of iron oxide corresponding to the iron charged in the metallic state. The method is identically the same as applied to any other metallic oxides. Any compound, ferro or alloy of two or more metals with iron can thus be readily made, such as, for instance, chrome titanium iron, tungsten titanium iron, chrome nickel iron, etc. It is enough to charge in the bath of aluminium a mixture of the proper metallic oxides in a given proportion to each other. In case of nickel, the metal nickel can even take the place in the iron bath when rutile is used, and a nickel titanium alloy be obtained. If copper titanium were desired, the copper is charged with the aluminium in the furnace and when melted rutile is shovelled in the furnace.

We have treated by this method, amongst other oxides, tungsten concentrates containing WoO_3 69.86 per cent, iron oxide 20.25 per cent, which could theoretically give an alloy containing 79.7 per cent tungsten. We obtained, in thirty minutes, with about 11-hp, 650 lbs. of a ferro-tungsten containing 76 per cent tungsten, that is, 97 per cent of what we calculated theoretically. The alloy could contain 0.60 per cent and 0.90 per cent of carbon and aluminium. None was found in the ferro. The weight of aluminium necessary for the reduction is obviously the same, let this metal be used in powder or in ingots, but the difference of prices of the two forms of aluminium is nearly as 2 to 1 in Europe, and over 2 to 1 here; prices of 70 cents per lb. having been quoted to us (per ton) for the aluminium in powder, as against 30 cents for aluminium in ingots. Assuming the same cost of ores or concentrates, the same losses in the operation, the same incidental expenses and manipulations, the advantage must necessarily remain, as to cost of the product, on the side of the use of aluminium in ingots. For instance, referring to the reduction of iron oxide by aluminium merely as an example, and for illustration's sake, since we required 0.484 kg. Al per kg. of iron, or, which is the same, 0.484 lb. of Al per lb. of iron, on this score of aluminium alone the cost per lb. of iron reduced would be for the powder $0.3388, and for the ingot $0.1452, for the prices quoted above, and for any other ones in proportion.

Applying our aluminium method to ferro-titanium, we have made alloys practically free from carbon containing from 0.12 per cent to 0.75 per cent carbon and from 10 to 75 per cent titanium by the ton. Such alloys are very well adapted for the treatment of steel, but for seasoning cast-iron we have used ferroes containing carbon from 6 to 8 per cent and more and obtained with carbon as reducer, as in this case the presence of this element is of no consequence.

Before entering into some details of the tests we have made with ferro-titanium, we may say that the electric furnace that we used for the reduction of oxides by aluminium did not present any particular features. It was the same that we used when carbon was the reducing agent. In fact, any approved form of arc furnace would secure the same results. We have adopted, as the simplest, the well-known typical form of the old Siemens furnace of 1879.

Our current was alternating single phase current of 25 cycles. The primary current was 2200 volts and 75 to 80 amperes, which could be transformed into a secondary current of 20, 40, 60, 80, or 100 volts (to adapt it to the requirements of the different cases), and corresponding amperage by means of a transformer. Thus each furnace was supplied with a current of about 150 kw, or, say, 200 hp.

The furnace consists of a masonry of graphite agglomerated with tar (it may be round or square), incased in a box or sheathing of iron or cast-iron, connected at the bottom with one of the bus bars of the current. It forms the one electrode. A central cavity in the graphite masonry constitutes the crucible, in which can be moved vertically, up or down, a pencil of carbon or a bunch of such pencils forming the other electrode and connected by means of flexible cables with the other bus bar of the current. The furnace can be left open at top or closed, preferably by means of plates cooled by a circulation

of water; the motion of the carbon pencil can be obtained by hand, or by proper devices such as chains, pulleys and wrench or automatically by the current itself, as is the practice with calcium carbide furnaces. Masonry of refractory material may line vertically the sides of the crucible, acting as a non-conducting material and preventing the contamination of the alloy by carbon when aluminium is used as reducer; many other details of arrangement may be conceived and adopted in order to confine the heat as much as possible in the furnace and increase the output for a given current, but the operation is the same. When using aluminium as already mentioned, the metal is first charged, the carbon pencil having been lifted up for the purpose. The pencil is then lowered down, the arc started, and the oxides charged around the vertical electrode in the bath. When operating with carbon, the mixture of carbon in some form and of the oxides or concentrates is charged around the carbon pencil, the arc having been first started between the bottom of the furnace and the carbon pencil.

FERRO-TITANIUM.

While the influence of metals introduced as such or more generally as ferroes, on the properties of iron and steel, has been ascertained sufficiently for some of them to make their use of common practice (for instance, manganese, nickel, silicon—considered as a metal, though not one—and more lately chromium), others, such as tungsten and molybdenum, have received more limited applications, and uranium and vanadium still more limited ones, owing to the rarer occurrence of their ores and the high price they command (especially the three latter metals). As to ferro-titanium, it was only known as a laboratory product, so to speak, some three or four years ago. Having given to the metallurgy of titanium and its alloy a special attention for several years and manufactured them on a large scale, we will enter into some details on their properties and uses.

We have made ferro-titanium, practically free from carbon, and containing from 4 per cent to 75 per cent titanium and more. What characterizes this ferro is the great infusibility, which is the greater as the percentage of titanium is higher. In this respect vanadium comes next and molybdenum immediately after. A 10 to 12 per cent ferro-titanium, with or without carbon, does not melt at the temperature of fusion ot cast-iron and steel, but it dissolves in the molten metal in the same manner as platinum dissolves in steel. According to experiments of Faraday and Stodard, platinum and steel alloy in all proportions "and platinum will fuse, in contact with steel, at a temperature at which the steel is not affected."[1]

Titanic oxide is not reduced by carbon at the temperature of the blast furnace or of a steel furnace, and all efforts to introduce titanium in iron or steel in this way have failed.[2] It is only by making a ferro-titanium and using it as a seasoner that it can be done, and it is only in the electric furnace that a heat sufficiently high for the reaction can be secured for the purpose. Titanium has a specific gravity of only 4.87 (Moissan) and, as a consequence, alloys containing a large percentage of titanium, especially if they contain also a large amount of carbon, have a low specific gravity. We have found 5.60 as the sp. gr. of a ferro-titanium containing some 35 per cent of titanium and about 8 per cent of carbon.

Owing to this low fusibility and this lightness, we have found it advisable not to use for steel alloys higher than 20 to 25 per cent titanium, and for cast-iron not over 10 to 12 per cent, and in that we are entirely corroborated by the German practice, limited as it is to alloys made by the Goldschmidt method.[3] Furthermore, the use of higher alloys does not seem to be justified; the action of titanium on iron appears to be peculiar, very small quantities of the ferro securing unexpected results. Even such a small percentage as 0.10 of 1 per cent titanium found in the finished product has secured the desired improvement, as our own experience has shown us, and this has been confirmed by these German tests and others.[4]

It has been thought that apart from such specific and still more marked influence that titanium may have, if present in steel or cast-iron in much more important quantities, its action is one of purification of the metal, by removing the occluded gases, such as oxygen and nitrogen. The oxygen is removed owing to the great heat of formation of TiO_2 (titanic oxide), which is probably of from ½ to 2/3 that of aluminium, from *tentative* experiments made by us, and the nitrogen is removed by the well-known affinity of titanium for this element in which titanium burns with incandescence at 800° C or thereabout, just like iron burns in oxygen. This could explain why the metal treated is more dense, more homogeneous, more free from small blow holes, and consequently much stronger.

An examination of the fracture of cast-iron and steel treated with titanium will convince any one on this respect, and a microscopic examination of the steel treated in Germany has revealed the presence of minutest crystals of cyano nitride of titanium.[5]

Owing to these causes or others, steel containing 0.10 per cent of titanium and high in carbon (hard steels), $C = 0.90$ to 1.227 per cent, have shown as "limit of elasticity" and "reduction of area" figures only met with nickel steel or "very mild" steels low in carbon. In other words, titanium increases the ductibility of high carbon steels, notwithstanding the tempering qualities, giving to the fracture of the metal a satin-like appearance.

Added to cast-iron, in the proportion of 1 to about 2 per cent of a 10 per cent titanium carbon ferro, that is, about 1 to 2 lbs. of alloy to 100 lbs. cast-iron, either in the crucible, the ladle or the cupola, it increases considerably both the tensile and transverse strength, some 30 per cent and more in certain cases. Our own tests with cast-iron have been very numerous and others have been made in car-wheel works by outside parties. The president of one of these large establishments, in a paper read before the Railway Club of Pittsburg, on November 28, 1902, says that "titanium gives greater density to the metal, surprisingly increases transverse strength and gives a harder chill and wearing qualities to the wheel—hardening the tread and strengthening all parts of the wheel, including the plates." In an official test made in a shipyard, an increase in strength "of about 29½ per cent over their ordinary castings" was reported as the result of tests made in crucibles. We could quote concerning the details many other examples showing similar improvements in the resistance of cast-iron thus treated with this alloy. The above is, however, sufficient, we believe, to justify us in the conclusion that ferro-titanium is a very promising ferro, and that, its beneficial influence on the properties of cast-iron and steel once definitely established beyond doubt, it would take a very prominent place amongst the ferroes used in the iron and steel industry.

It would prove the cheapest of all of them, let the reducer be carbon or aluminium, as the raw materials can be obtained at a price as low, if not lower than that which ordinary ores command, and are found in abundance almost everywhere.

Rutile itself (titanic oxide) has been discovered in extensive deposits in Virginia, and we are told that a 90 per cent to 95 per cent titanic acid concentrate can be readily prepared at a very favorable figure, much lower than is possible with the concentrates of the rarer metals; specially so were there a sufficient demand for rutile to justify it.

The use of rutile, however, is only justified as more economical than that of titaniferous iron ores whenever ferro-titanium is obtained free from carbon by the aluminium meth-

[1] Perry's Metallurgy, London, 1864, p. 178.
[2] Ibidem, p. 168. Howe's Metallurgy of Iron and Steel. First Edition, p. 86.
[3] Stahl and Eisen, June, 1901, Duesseldorf meeting, Volume XXI., No. 11.
[4] Ibidem.
[5] Stahl and Eisen, the article quoted above.

od, since the absence of material quantities of oxide of iron in the rutile reduces the amount of aluminium to be used in making the ferro or the alloy by all the quantity required to reduce the oxides of iron present in the ores. But this is true only if the price of rutile is not prohibitive.

Otherwise the titaniferous ores are preferably adopted as raw material, and as we have seen that the lower alloys are likely to be better adapted for industrial applications, they would prove sufficient. In this respect we will add that, should such be the case, should the price of rutile prove a serious item, and should alloys of the highest percentage of titanium be desired, we have used a method by which an "artificial rutile," so to speak, a concentrate of titanic oxide, can be cheaply secured. The ores we disposed of in our manufacture contained, some of them, 15 per cent TiO_2, 80 per cent oxide of iron and 5 per cent gangue; others 40 per cent TiO_2, 55 per cent oxide of iron and some 5 per cent of gangue.

By smelting these ores in our electric furnace with addition of carbon in quantity just sufficient to reduce the oxides of iron and not the titanic acid (the last of the two oxides which is reduced in all cases), and operating with a moderate current, we have obtained a regular pig iron containing no or but a few hundredths of 1 per cent of titanium and a slag in which was concentrated all the titanic acid of the ores, that is, with the first ore, some 75 per cent of titanic acid, and with the second some 88 per cent, and practically free from oxide of iron or containing but such small quantities (1 per cent to 2 per cent or thereabout), as are met with in blast furnace slags. This "igneous concentrate," as we have called it, this sort of "artificial rutile," forms an excellent and cheap material to be reduced economically by aluminium. The pig iron smelted like the metal which has been smelted from titaniferous iron ores in the blast furnace possesses valuable properties. At any rate, it commands a price fully as high as that of very good pig iron, which price offsets the expense of the production of the "concentrate" to such an extent that the cost of the latter becomes, to all purposes, nominal.

NEW YORK MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

The American Institute of Mining Engineers held its eighty-fifth meeting in New York City from October 13 to 17.

On the morning and afternoon of October 14 sessions were held in Schermerhorn Hall of Columbia University, devoted to the reading and discussion of papers on mining and general metallurgy, and on the morning of October 15 a session in the hall of the American Society of Mechanical Engineers, devoted to the reading and discussion of papers on the metallurgy of iron and steel.

During this latter session the secretary, Dr. R. W. Raymond, made an interesting announcement concerning the result of ballotting on the proposed gift of Mr. Carnegie for a Union Engineering Building. He referred to Mr. Carnegie repeatedly as the distinguished fellow member of the American Institute of Mining Engineers. Some doubts had originally been expressed as to the attitude of the Institute of Mining Engineers in this matter for the reason that the Institute had always endeavored to be an *American* institute, representing the total membership and not to benefit specially the New York City members. When, many years ago, the headquarters were transferred from Philadelphia to New York, it had been promised that the Institute would never become a society for the special benefit of New York members. This promise has been truly kept. In fact, when the suggestion was made to open club rooms for New York members, and for other members visiting New York, Dr. Raymond suggested that such a club should not be connected with any national society. From this suggestion resulted the foundation of the Engineers' Club. As this policy had always been followed by the council of the American Institute of Mining Engineers, it seemed doubtful what position the institute would take towards Mr. Carnegie's scheme of a Union Engineering Building.

The council, however, declared heartily in favor of this scheme, and the question of the advisability of the Institute of Mining Engineers joining the other societies in this scheme was submitted to all the members for a letter ballot. Out of about 3500 members, 1600 voted, and Dr. Raymond stated "about 1600 votes were in the affirmative and 5 or 6 voted against it." The argument presented by the latter was that the society had been run so smoothly for so many years that it seemed not advisable to change anything. Dr. Raymond pointed out that this smooth running of the affairs of the society was mainly due to two principles which were always followed, and which should also be strictly adhered to in future. First that the council of the Institute is omnipotent second, that this omnipotence refers only to a very limited circle of duties. Neither the council nor even the society itself is allowed to adopt resolutions for or against, say, the metric system or to adopt rules of standardization. This does not prevent the Institute from having a committee appointed for a discussion of such questions or to discuss it in a general session; but what the Institute is after is the information gathered by such committees or brought out in such discussions, and not the adoption of resolutions. "We do not endorse anybody's theory, we do not endorse our own." The carrying out of the Union Engineering Building scheme will necessitate some changes in the constitution of the Institute of Mining Engineers. They will be submitted to the members at the next general meeting in February, 1904.

On the afternoon of October 15 optional trips to metallurgical plants in the vicinity of New York had been arranged, invitations having been extended to the Institute by the following concerns: The American Smelting and Refining Co., the Balbach Smelting and Refining Co., the Bayonne Refinery of the Standard Oil Co., and the Nichols Chemical Co. Mr. Nichols personally conducted the latter party and his company had arranged refreshments for the visitors. On the evening of October 15 a reception and dance were given at Sherry's. On October 16 an inspection of the Rapid Transit Subway had been arranged for the forenoon and for the afternoon a trip by water around Manhattan Island. On the evening of the same day Dr. G. F. Kunz and Dr. Charles Baskerville presented a paper on "the action of radium, Röntgen rays and ultra-violet light upon minerals" at the hall of the American Museum of Natural History.

In the whole 50 papers were on the programme, of which, however, only a small number were really presented.

The paper that would probably be of the greatest interest to the readers of Electrochemical Industry was by Mr. F. A. Kjellin, of Gysinge, Sweden, on his electric steel furnace at Gysinge, which is a furnace without electrodes, the charge forming the single secondary turn of an alternating current transformer. In the absence of the author it was read by Dr. Leonard Waldo, who explained that for iron and steel an arc furnace gives too high a temperature, while with a resistance furnace with electrodes impurities are introduced into the charge from the electrodes. The chief features of a resistance furnace based on the induction principle are freedom of the charge from contact with any form of fuel, and from any contaminations from the electrodes. Mr. Kjellin's paper itself did not seem to contain much that has not been already published in this journal (see Electrochemical Industry, December, 1902, p. 141; July, 1903, p. 376; September, 1903, p. 462).

Other papers of interest to our readers are "Steel for 'Third Rails,'" by J. A. Capp; "Metallurgy of the Homestake Ores," by C. W. Merrill; "The Cyanide Plant and Practice at the Ymir Mine, West Kootenay, B. C.," by E. C. Holden; and others. Since limitations of space prevent us from giving abstracts of these papers in the present issue, we will reserve them for our next number.

ALUMINOTHERMICS.

By Hans Goldschmidt, Ph. D.

At the request of the editor of Electrochemical Industry, the author has written the following article in which the practical applications of "aluminothermics" are chiefly considered, to supplement an article of Dr. G. P. Scholl (page 175 of the January issue of this journal), in which mainly the thermochemical side of the question was discussed on the basis of former publications of the present writer.

Up to the present, aluminothermics has been commercially successful in two fields; first, in the production of metals, free from carbon, such as are needed in the manufacture of certain special steels; second, for welding purposes with the aid of thermit. Recently a third application has been developed, namely, the improving of iron and steel castings.

Production of Pure Metals Free from Carbon.

Originally the aluminothermic reaction was made use of only as a means for preparing pure refractory metals, for producing chromium, manganese, ferrotitanium, ferroboron, etc. People not familiar with the subject may perhaps be surprised that such a simple reaction as the aluminothermic one had to undergo a special extended practical development. Yet in the case of every metal the evolution of the aluminothermic method of making the pure metal in uniform quality and with a high efficiency, involved very considerable work, which is not surprising if the reactions taking place in such a process are considered in detail. For this reason

FIG. 1.—RAILWELDING ON TRACK (DRESDEN, 1903).

it was specially gratifying to the author, that when, several years ago, he showed to Prof. Moissan the method of producing on a large scale chromium and manganese, free from carbon, the first question which the latter asked was how many years of work had been required to render the reaction so simple and smooth.

All thermit mixtures consist of nearly equivalent quantities of a metallic oxide and aluminium, and what is generally called "thermit," consists mainly of a mixture of oxide of iron and aluminium, as anybody who should be interested in preparing it himself can easily find out.

Comparison may be made with other reagents which also yield an exothermic reaction, although with a quite different effect. Gunpowder and dynamite are, for example, of very simple composition and their manufacture is to some extent easy. Many anarchistic crimes were possible only for the reason that it is not very difficult to make dynamite. But while such reagents made by laymen may explode, a regular, sure effect, as is required for engineering purposes, cannot be guaranteed. The technical manufacture just of dynamite is a very subtle matter.

The conditions are similar with gunpowder. Boys make powder by putting saltpeter, sulphur and charcoal together and really thus get a mixture which burns, but it has not the explosive value which meets modern technical requirements. It is well known that in all such mixtures the physical nature and the distribution of the materials is of main importance, so that even with the same, or with nearly the same, chemical composition very different effects may be produced. We may refer to the different kinds of gunpowder according to the different sizes of the grains. The main requirement is the uniformity of the product. Similarly, the manufacture of a technically useful thermit required much work; especially details of a physical nature had to be studied and had to be continually watched during manufacture, while the design of special machines and devices also became necessary. Most of these details cannot be expressed in form of prescriptions or briefly described, nor are they of general interest.

Besides the pure metals and alloys formerly made in this way, it has recently become possible to produce pure fused molybdenum. It is a metal of a gray color, like steel, and of dense structure. It contains as chief impurity about 1 or 2 per cent of iron, besides very small quantities of silicium, so that its purity is 98 to 99 per cent. Molybdenum was

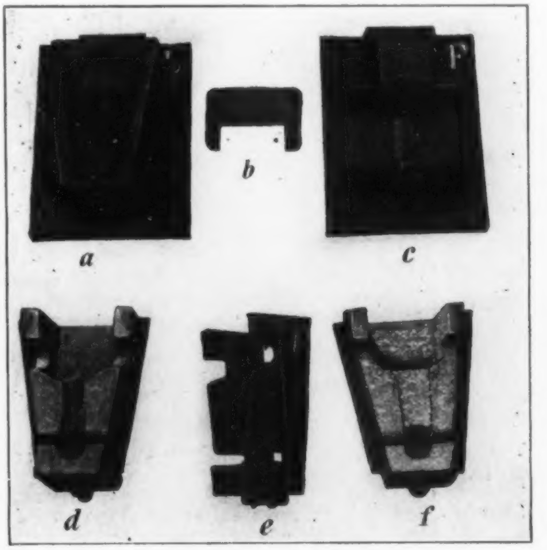


FIG. 2.—RAILWELDING PROCESS.

a Model for the lip side with mould shell. *b* Appliance used when ramming the sand in. *c* Model for tread side. *d* Finished half of mould for lip side. *e* Half of mould shell for tread side. *f* Finished half of mould for tread side.

formerly made only in powdered form, by reduction of the acid by carbon (like tungsten) and has found application in the manufacture of some special steels. The author now produces also a tungsten alloy of high percentage, with the specific gravity 14.5, which may be easily machined and is very strong. It is used for ballistic purposes.

Since recently metallic silicon with a purity of 98 per cent has been placed on the market at a low price, it appeared promising to substitute silicon wholly or partly for aluminium for the purpose of the thermic reaction. The high value of the heat of oxidation of silicon seemed to justify such hopes, moreover the possibility seemed promising to get, by the simultaneous use of silicon and aluminium, more easily fusible silicate slags. However, the result of these experiments was negative. For instance, equivalent mixtures of oxide of iron and silicon or of oxide of nickel and silicon, cannot be ignited like thermit.

Even more peculiar, however, are mixtures of both silicon

and aluminium with oxide of iron. Even if only 10 per cent of an equivalent mixture of silicon and oxide of iron are added to ordinary thermit, this addition delays the progress of the reaction to such an extent that this thermit becomes unsuitable for welding purposes. While the temperature produced by the heat of oxidation of aluminium starts the reaction between the silicon and the oxide, yet the latter reaction is considerably slower than the formation of Al_2O_3. The slag is somewhat more easily fusible, but the delay of

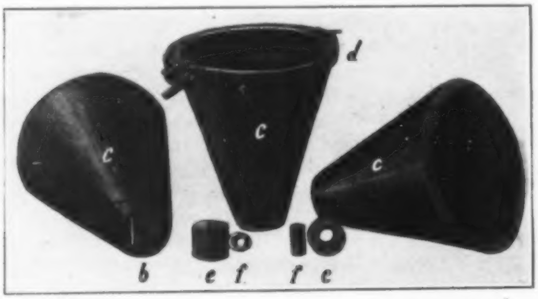


FIG. 4.—CONICAL CRUCIBLES LINED WITH MAGNESIA.

b Flow hole. *c* Sheet-iron shell. *d* Protecting ring. *e* Large magnesia stone. *f* Small magnesia stone (thimble).

the reaction—and the loss of heat due to this delay—more than counterbalances this gain.

The result will be similar, if one tries to aid the formation of $Si\ O_2$ by larger additions of silicon, and the reaction even stops entirely if about 50 per cent of silicon are added; a sintered mass is then formed. It is possible to aid the reaction somewhat by means of external heating, but the improvement is only slight and does not lead to a practical success.

External heating, as an accessory to extremely smooth aluminothermic reactions, is essentially nonsensical. This is evident, because, in view of the heat evolved in the few seconds by the reaction itself, an appreciable supply of external heat is impracticable even with the aid of electrical energy. Reference may be made to the calculation of the "energy density" of thermit (*Zeit. f. Anorgan. Chemie*, 1902, September 28, and ELECTROCHEMICAL INDUSTRY, January, 1903, p. 177); the figures there mentioned show the uselessness of an external supply of heat.

FIG. 3.—WELDED RAIL.

It is also useless to preheat the mixture in order to start the reaction. It is possible to always add new material to the mixture after the reaction is started, so that the glow is covered. By this means the mixture is not only completely dried, but strongly preheated, before the reaction starts, yet an acceleration of the reaction of the thus preheated mixture is not observed.

THERMIT FOR WELDING.

The large field of welding processes with the aid of thermit—which is at present the most important application of aluminothermics—has been considerably broadened in recent years with respect to the evolution and application of the methods for such purposes. Especially the welding of tramway rails (Fig. 1) by the thermit process has come into a steadily extending use, and by many tests—which have been conducted with great care, especially in England—this method was found to be the best and cheapest at present available. A special committee, appointed for an investigation of the process a year ago by the city of Leeds, in England, has arrived at this result, not only by special stress-strain tests, but

FIG. 5.—RAILWELDING WITHOUT CLAMPS.

by a visit to various roads in Germany (in Dresden, Berlin and Brunswick), in which rails welded together by the thermit process had been in use for about three years. It was found that the welded joints could not be distinguished from the rail itself. In Leeds several miles of rails have already been welded together, and a larger number of other cities,

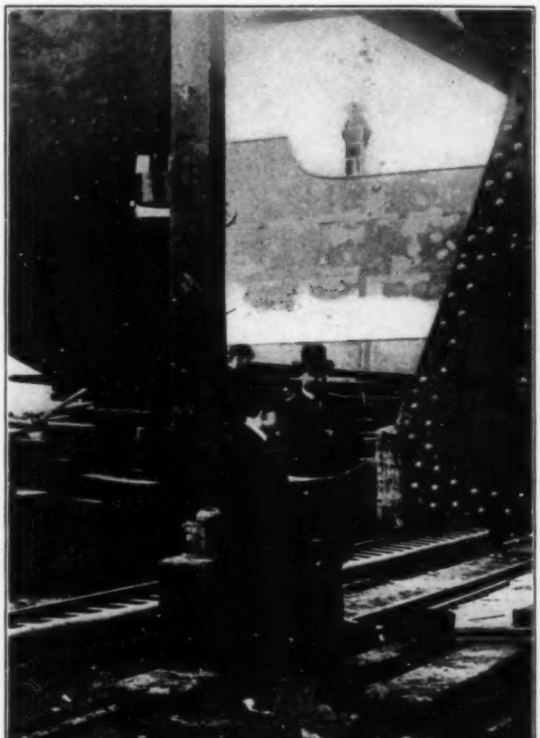


FIG. 6.—STERNPOST OF S. S. SEVILLA WELDED IN DRY DOCK.

like Glasgow, Nottingham, etc., are also introducing the system. After nearly four years of constant use, the general applicability of the thermit process is now to be considered as proven so that some roads use it as the only method of joining rails together. For instance, a large English com-

pany is now welding tramway rails in Singapore, to an extent of twenty-five miles, by the thermit process.

The characteristic features of the process are the simplicity of operation and the absence of any larger apparatus. There are required only rail clamps, a crucible with 15 to 20 lbs. of thermit and a small mould which is placed around the joint. Experience has shown that welding with thermit is performed more quickly than fixing fish-plates with copper bonds.

An exact description of this method of welding rails may now be given. For every cross-section of rail a special model is made which serves for making the mould to be placed around the joint. By a very great number of tests

FIG. 7.—BROKEN STERNPOST OF S. S. SABENICO (TRIESTE) WELDED WITH THERMIT.

the required thickness of the small channels between rail and mould wall has been determined. The dimensions of these channels vary between about 10 and 30 mm. (0.4 and 1.2 inch) thickness and 30 to 100 mm. (1.2 to 4 inches) length; they are different according to the various dimensions of the head, web and foot of the rail cross-section (Fig. 2). The thermit-iron which first runs out of the crucible, flows around base and web and melts them together. For this purpose narrow channels are preferable. Simultaneously the molten slag flows around the head of the rail and heats it up to welding temperature. The whole cross-section of the rail is thus uniformly heated to welding temperature, so that a bending of the rail ends is prevented. Finally, a few minutes after the reacting mass has flown into the mould, the set-screws of the rail clamps are drawn together by one turn (which corresponds to about 10 mm. or 0.4 inch) and an absolutely uniform weld is thus obtained. The joint is even

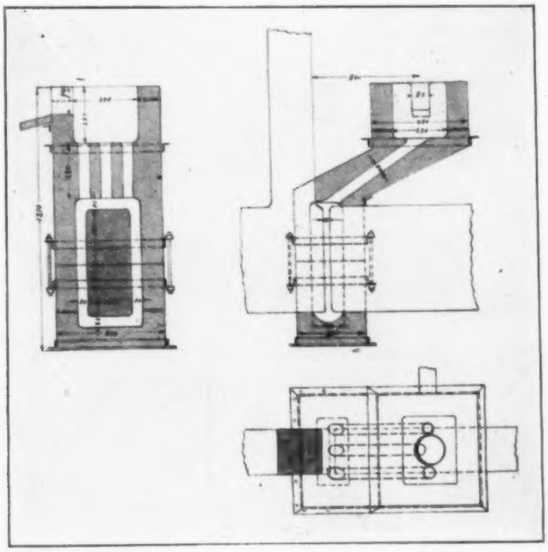


FIG. 8.—MOULD FOR SEVILLA REPAIR.

stronger than the rail on account of the welded mass of malleable thermit iron. (Fig. 3.) The small up-set of the joint of the rail is filed off by hand or removed with a grinder.

FIG. 9.—BROKEN STERNPOST WELDED ON DUTCH STEAMER.

The joint will become permanently invisible after a few cars have rolled over it.

From the model, which is mostly made of aluminium in order to be handy, the mould is made in the ordinary manner known to every moulder. Since no artistic castings are re-

quired, the moulding can be made by any young workman. Any moulding material may be used which is suitable for steel castings, for instance, a mixture of 80 parts of sand with 20 parts of china clay, or a mixture of yellow clay and sand in equal parts. The drying of this mass is accomplished in

FIG. 10.—WROUGHT-IRON TUBE BENT AT WELD WHILST COLD.

about four hours, at a temperature of about 300 to 400 degrees Centigrade. The mass had best be stamped into a sheet-iron box placed around the aluminium model. This box serves for a very great number of weldings. The mould is fastened to the rails and any apertures are closed by clay, etc. Its cost is only a few cents.

Before welding, the rail ends are slightly preheated with a soldering lamp, or some kindling wood, to facilitate the removal of dirt and rust, which is done with the aid of a wire brush. The use of a sand-blast has been found superfluous.

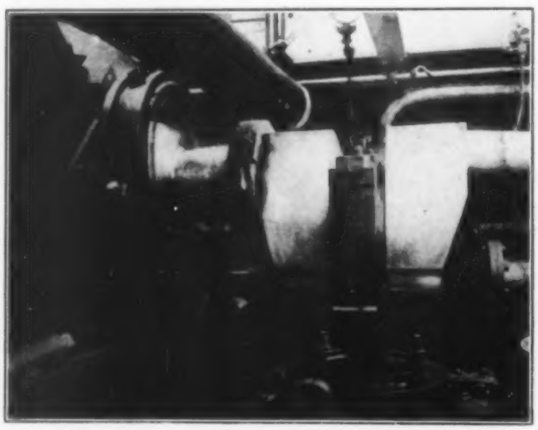


FIG. 11.—CRANKSHAFT REPAIRED ON BOARD A RHINE STEAMER.

The cross-sections to be butted are cleaned with a file. This is all the preliminary work required and does not take much time.

The welding of the rails is always done by the same company which lays the rails, since the method of welding is easily mastered by any intelligent workman after he has made a few weldings. The most important point is that the rails are placed in the true, straight line to avoid welding in deviations; this has, of course, nothing to do with the welding process itself. True, a certain accuracy is required during the welding process, but that it is not difficult is proven by the fact that quite a number of companies have quickly familiarized themselves with the process.

The crucibles consist of a sheet-iron mantle with a magnesite lining. By placing a cast-iron cone into the mantle, a free space is formed between cone and mantle which is filled with heated magnesite tar. The crucibles with the cone are placed for about two hours into a furnace, and heated up to red heat and are then ready for use. The large tramway companies make these crucibles themselves. They serve for about twenty-five castings, so that the item of crucible wear and tear per joint is insignificant. In the bottom of the crucible there is a perforated cone of magnesia stone. It contains a second one which is also perforated and serves as "thimble." The latter may be easily replaced after a number of castings. (Fig. 4.) Between both cones of magnesia stone there is only a layer of paper. By the use of the thimble it is possible to render the diameter of the flow

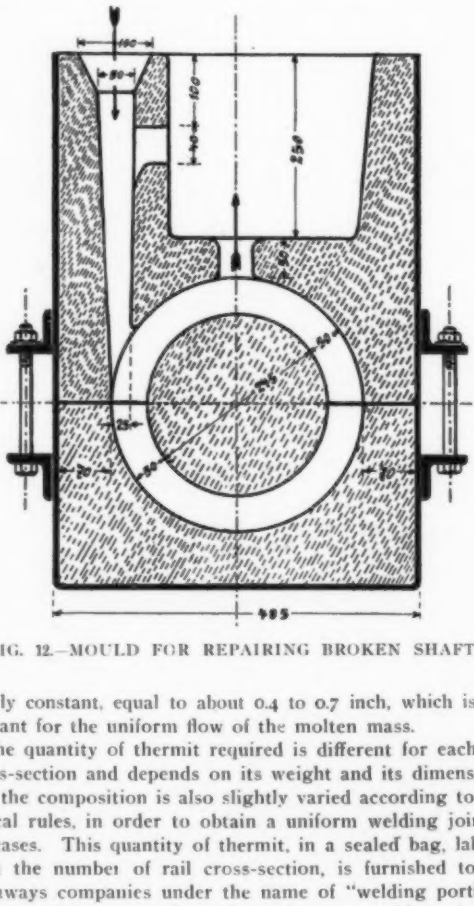


FIG. 12.—MOULD FOR REPAIRING BROKEN SHAFTS.

nearly constant, equal to about 0.4 to 0.7 inch, which is important for the uniform flow of the molten mass.

The quantity of thermit required is different for each rail cross-section and depends on its weight and its dimensions, and the composition is also slightly varied according to empirical rules, in order to obtain a uniform welding joint in all cases. This quantity of thermit, in a sealed bag, labeled with the number of rail cross-section, is furnished to the tramways companies under the name of "welding portion." Since the latter generally make their own moulds and often their own crucibles, the welding portions and the rail clamps are the only things to be bought.

In certain cases, even the rail clamps are not required, as, for instance, when it is required to weld old rails together which had already been used. (Fig. 5.) After removing the loosened fish-plates, a proper mould is placed around the joint and the reacting mass is passed into it from the crucible. In this case the heads of the rails are not welded together, or only partly, but the bases and webs are completely welded together up to nearly the rail head. Moreover, the joint is strengthened by the thermit-iron around the base.

This method, while giving a perfectly reliable joint, requires less time, because no rail clamps are used, nor has the up-set to be filed off. A heating of the rail heads by the slag to the temperature of welding must also occur in this

case, in order to prevent a bending of the rails. If there is a space between the rail ends, it must be filled, before welding, with a shim. The shims may be pressed between the ends of the rails, for instance, by raising the rail ends by means of a wrench, in order to broaden the distance between the rail ends at the top. If this is done, it is often possible to produce a welding together of the rail heads. This is always preferable, as the thermit process is specially elegant for the reason that after the rail heads are welded together the joint is invisible.

For this reason, on old tracks which need repairing (of course, only on such tracks where the wear and tear of the joints has not gone too far), it is generally tried to weld by the following method: The rail clamps are fixed on the rails and by drawing the screws backwards, the space between the rail ends is enlarged by 8 to 10 mm. (0.3 to 0.4 inch). The thickness of the shim exceeds by 8 to 10 mm. (0.3 to 0.4 inch) the original space between the rails. After the run of the molten thermit is completed, the rails are then butted together, as in the ordinary welding process, but care is to be taken that the length of the embedded track is not shortened.

FIG. 13.—WELDING OF A CONNECTING ROD.

If the track is laid in a paved street, it is necessary to loosen the pavement sufficiently before and behind the joint. With very firmly embedded rails this method is, however, impossible, and no welding together of the rail heads can be made. Of course, in considering the advisability of welding old rails together, the special conditions of each case must be taken into account. It has been undertaken with the best success, for instance, without rail clamps in Brunswick, and in several places in France, like Rouen, Havre, etc.; with clamps in Italy, for instance, in Genoa, even with a rather firmly embedded track.

A large number of tests were made by the author as well as by tramway companies in order to determine the strength of the welded joint, and to see how the portions of the rails, heated by the thermit, are thereby influenced. The strength produced in the head of the rail by welding is about 80 per cent the strength of the material, even with very hard material. A test, recently made by a company, gave 87.75 per cent of the strength of the original material.

Test pieces for tension tests were also cut from rail sections which had undergone a thermit-iron casting in the same way as though a welding should be made, in order to give the piece the same heat to which the rail ends are exposed during the welding process. Since the whole welding zone is only 6 inches long, while the test rod had a length of 8 inches, the whole heating zone was inside the test rod.

The figures which refer to a non-heated portion of the rail

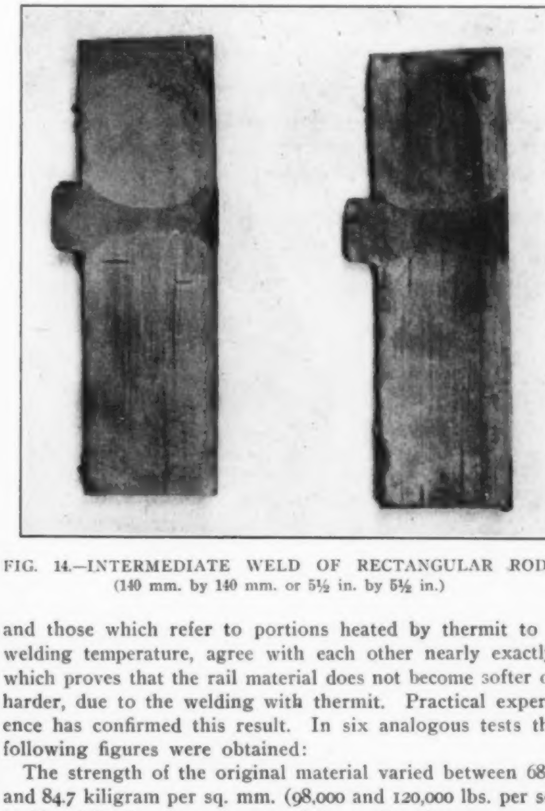


FIG. 14.—INTERMEDIATE WELD OF RECTANGULAR RODS (140 mm. by 140 mm. or 5½ in. by 5½ in.)

and those which refer to portions heated by thermit to a welding temperature, agree with each other nearly exactly, which proves that the rail material does not become softer or harder, due to the welding with thermit. Practical experience has confirmed this result. In six analogous tests the following figures were obtained:

The strength of the original material varied between 68.9 and 84.7 kiligram per sq. mm. (98,000 and 120,000 lbs. per sq. inch), while the elongation was between 8 and 15.5 per cent. For the six test pieces, around which thermit had been cast, the strength varied between 66.2 and 80.8 kilogram per sq. mm. (94,000 and 115,000 lbs. per sq. inch), while the elongation varied between 9.5 and 12.5 per cent. The average values were about the same.

A large number of test pieces were taken from head, base and web of rail joints, the cross-sections of which had been welded together. The strength varied here between 55.6 and 67.8 kilograms per sq. mm. (79,000 and 96,000 lbs. per sq. inch). The average value is above 62 kilograms per sq. mm. (88,000 lbs. per sq. inch). It follows that only the very short welding section itself (a piece of 1 to 2 mm. or 0.04 to 0.08 inches length) has undergone a slight decrease of strength due to the welding processs. The rail material, therefore, is not changed in the neighborhood of the joint, while the latter, by the welding process, is made thicker than the rail itself.

If the rails, after having been welded together are crushed or broken, the breaking point is always outside of the welded joint, and mostly even outside of the welding zone. An ex-

planation for the excellence of the joint, obtained with the thermit process, is that the welding takes place under complete absence of air, and that an always uniform quantity of heat—which does not depend on the welder—is supplied to the welding point by the exactly weighed "welding portion."

A further application of thermit is on electric railways of the third rail type for joining the third rail together. It is well known that copper bonds are unsatisfactory for this purpose, since a good, permanent joint cannot be guaranteed. The transition resistance increases with the time and requires repeated and extensive repairs. Simpler, more reliable, and at the same time considerably cheaper is the method of welding rails; the weld may only be partial. On the suburban road from Berlin to Grosslichterfelde the Union Electricitäts Gesellschaft of Berlin has recently used this method on a track length of about 22 kilometers (13.6 miles). In this case an electric connection of three lengths of rail (45 meters, or 148 feet) has been accomplished by welding on a small head of thermit-iron. An ordinary fish-plate strengthens the mechanical connection of the rails.

Repairs of Castings.

Recently the use of thermit has become very important for the repair of broken stern posts of steamers. (Fig. 6). To replace a broken part by a new one is not only expensive, but what is of still greater importance, much time is lost, while the steamer cannot be used, but is in dock eating up interest. By means of a repair with thermit, the time required for the repair may be reduced from months to a few days, or to a still shorter time. The repair which otherwise requires several ten thousands of marks (10,000 marks = $2,500) can now be made for a few hundred marks by the 'longshoremen on the dock, because the use of thermit is very simple and may be quickly learned. (Fig. 7).

Even great repairs in which several hundred kilograms (1 kg. = 2.2 lbs.) of thermit are used in one reaction, are very simple. The principal requirement is to apply a mould of proper dimensions. (Fig. 8). That this is easily made from given models, has been proven by several very successful weldings of stern posts in Holland, which were made in loco according to brief instructions received by mail. (Fig. 9).

Welding of Wrought-Iron Tubes and Solid Rods.

Reference may also be made to the well-known method of welding wrought-iron tubes together with the aid of thermit. The number of such weldings which have actually been made is estimated at 30,000 to 40,000. This method of thermit welding is cheaper than a good flange-joint, and may be made even at a place which is not easily accessible. It is of special advantage for tubes under high pressure or for the transport of liquids which attack nearly every material for packing, such as alkalies, petroleum, etc. (Fig. 10).

In these cases a pure butt welding of the tube ends is made, a small mould of sheet-iron being applied, surrounded by sand. From a crucible the molten thermit is poured into the mould. The corundum flows out first, so that the tube is at once surrounded with a thin layer of corundum about 1 mm. (0.04 inch) thick, so that the thermit-iron which flows out afterwards cannot touch the tube directly and therefore cannot melt it through. For every size of tube up to about 6 inches a simple table has been worked out from which to find at once the dimensions of the mould, its distance from the tube and the quantity of thermit to be applied.

Similarly, in special cases, a butt end welding of solid rods may be made. For this purpose also a similar table has been worked out.

It is especially remarkable that the aluminothermic butt end weldings are of excellent quality. We have already mentioned above that even hard rail material gives a good weld. In the following table the results are given of four 1½ inch rectangular rods of somewhat soft material of Martin cast-iron welded together by thermit. The breaking point of normally decreased diameter was in all cases outside of the welding zone:

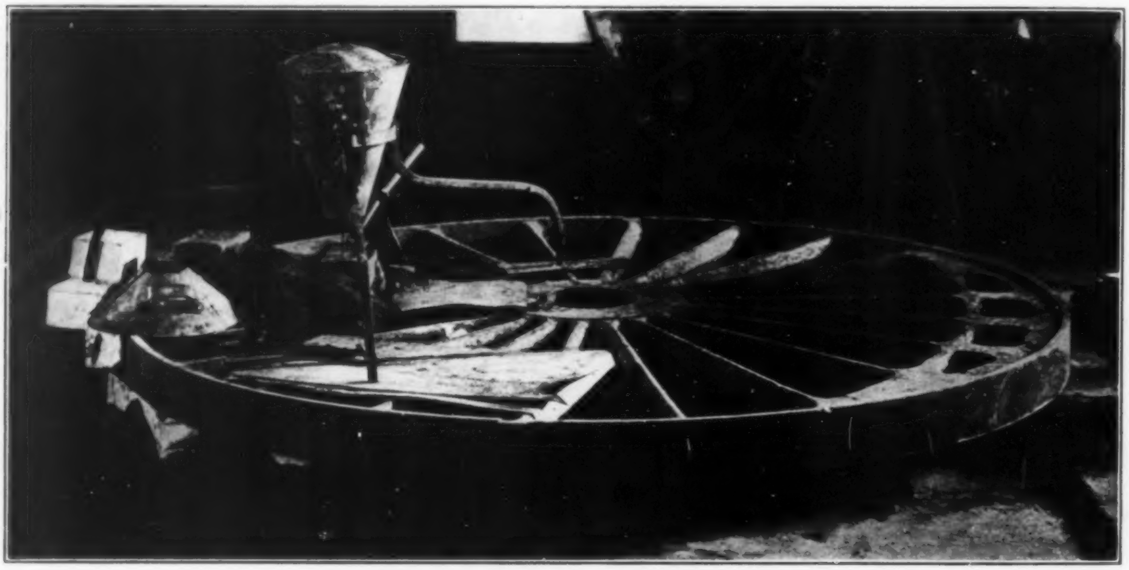


FIG. 15.—REPAIR OF A LARGE ENGINE WHEEL.

Rod 40 by 40 mm. (1½ by 1½ inch)	Analyses.				Breaking Point in kg. per sq. mm.	Elongation in % Referring to 200 mm. Original Length.
	C.	Si.	Mn.	S.		
1	0.10	0.05	0.27	0.06	44	20.5
11	0.11	0.04	0.37	0.06	41.7	20.5
111	0.08	0.03	0.34	0.07	44.4	22

In most cases in which broken rods or shafts are to be welded together with thermit, the pure butt end welding will not be used, but a so-called automatic method as is used for rail welding. (Figs. 11 and 12). A table has been worked out which gives the quantity of thermit required and the

dimensions of the mould, which may be made from 80 parts of sand with 20 parts of coalin.

Instead of merely running metal round broken shafts, in many cases the so-called combined intermediate and annular welding method may be used. In this case the shaft ends are fixed at a distance of 10 to 20 mm. (0.4 to 0.8 inch) and a proper mould is then applied. The advantage of this method is that the joint becomes a more intimate one, since the thermit-iron flowing through the intermediate space dissolves a part of the shaft ends so that these are firmly welded together with the intermediate casting. In this case the length of the thermit-iron ring is only about one-half that required in the former case. A table giving the exact figures for the thermit required and for the dimensions of the mould has been worked out for this purpose.

"Anti-Piping" Thermit for Improving Iron and Steel Castings.

The third field of application mentioned in the introduction of this article is for improving iron and steel castings. The

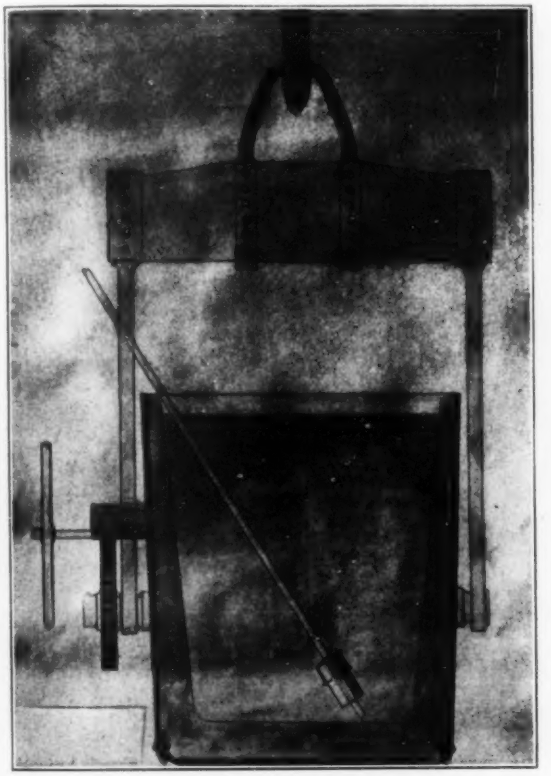


FIG. 16.—SHANK WITH TITANIUM THERMIT BOX IMMERSED.

methods used in this field have been worked out by my associate, Chief Engineer Mathesius.

According to the principle common to all applications in this field, the thermit is brought to reaction below the surface of the metallic bath. At a point within the bath a high temperature is therefore produced. For this purpose the thermit is filled into a tin box which is fixed at the end of an iron rod, and by these means the box is held under the surface of the molten metal. For further details the reader is referred to the accompanying illustrations. (Fig. 16).

In the first line this method is used in crucibles with molten cast-iron. In these cases not ordinary thermit is used, but a kind which gives off an alloy of iron with titanium, so that a quantity of titanium is introduced in statu nascendi into the cast-iron. The author has formerly applied this titanium-thermit (really ferro-titanium-thermit) directly to the surface of the molten cast-iron. Good results are also obtained in this way, but the new application of bringing the thermit below the surface of the bath is more reliable and more economical, smaller quantities of thermit being sufficient. That the thermit really burns off without unburned portions coming to the surface, is explained by the fact that the slag formed during the reaction surrounds the unburned particles so that they stick to the iron rod. The tin box is dissolved almost immediately and serves only as a means to hold the thermit together before the reaction starts in the metal bath. The reaction in the cast-iron bath lasts only one or two minutes and produces a very complete stirring of the whole bath. A kind of poling of cast-iron is thus produced, gases and particles of slag being driven upwards, so that the iron appears to be heated to a higher temperature. The real increase of temperature is, of course, only small, since according to the size of the crucible of 200 kilograms (440 lbs.) up to several thousand kilograms, only ¼ to 1-16 per cent of titanium is used. The introduction of titanium is made in order to bind small quantities of nitrogen. According to the results so far obtained, a small addition of titanium to cast-iron seems to increase its tenacity and to produce a finer grain.

This method has been applied with the best success by several foundries, and is of special use in plants in which the production of castings free from pores is of special importance, that is, in mills in which machine castings of all kind are made.

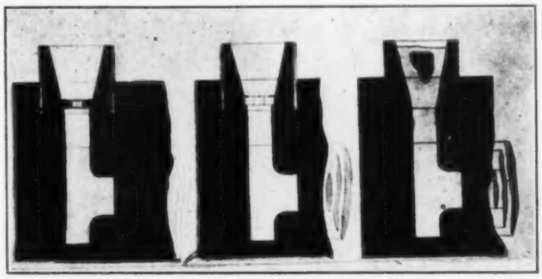


FIG. 20.
BEFORE DURING THE CASTING AFTER

By the reaction described it is not only possible to produce a casting absolutely free from pores, but it is also possible to introduce into the crucible desirable additions of other materials, for instance, of ferro-manganese. After such a so-called "box reaction" has been carried out, the manganese—which may, for instance, be assumed as 1 present—is found uniformly distributed in the casting. The same method may be used for an addition of nickel for making crucibles used in evaporating caustic alkalies in the chemical industry. In this case it is better to use the nickel in form of nickel thermit, which has been ignited previously in another ladle, and is then poured into the crucible together with the slag. The uniform mixing of the nickel is then produced by means of a "box" reaction. Nickel thermit, containing 60 per cent of metallic nickel, is used in the proportion of about 1 per cent of the contents of the ladle, and with such nickel addition about 50 per cent more charge can be treated than without nickel.

Another application of the so-called "box reaction" is important for steel castings, and especially for casting large steel ingots, to prevent the familiar phenomenon of piping. In the heads of such blocks hollow spaces are found which mostly cause 30 to 40 per cent of loss. (Fig. 17). Many means have been tried to overcome this disadvantage. Only recently a method has been worked out in which the whole block after the casting is completed is put under a very strong pressure. On account of the large apparatus required, this method is

very expensive, but it shows how important it is considered to overcome the above disadvantage.

The thermit process as used for this purpose consists in introducing a box of so-called anti-piping thermit into the block with the aid of an iron rod, in exactly the same way as described before. According to the size of the block, the box is suspended about one meter (3.3 feet). (Fig. 18.) The reaction is completed in this case in a few seconds. The box is introduced, of course, only after the piping has been formed, that is, after about 15 to 20 minutes. The head layer, which has already become solid, is broken through for this purpose. Immediately after the reaction is completed, steel, which had been kept prepared for this purpose, is poured into the open hole. The method is really very simple, and one learns very quickly at which time to introduce the box. Moreover, the method is very cheap, only about 5 kilograms of thermit being required for blocks of 10 to 20 tons of weight. In Fig. 19 a block is shown which had been treated by the method of Mr. Mathesius. After the treatment relatively very small pores were found, and only in the upper part of the block as shown in the illustration, so that the loss was only very few per cent. The method has also been applied for very large steel castings to revive steel which had become plastic in the runners. Fig. 20 shows a steel casting (large cogwheel). In this the anti-piping thermit is placed at the bottom of some runners in an annular box with concentric walls, containing about 2½ lbs. of thermit. There is in this case no need to thrust the box in by means of an iron rod. The piping will not protrude into the piece, but will be kept right at the head of the runner. The difficult operation of casting long stern posts of vessels can be facilitated by inserting in several places boxes of this thermit. On account of the long way the steel has to travel it has a tendency to grow plastic. But coming into contact with thermit, its temperature, and thereby its fluidity, is increased again.

FIG. 17.—STEEL BLOCK SHOWING DEFECTIVE HEAD (PIPING), WITHOUT ANTI-PIPING THERMIT.

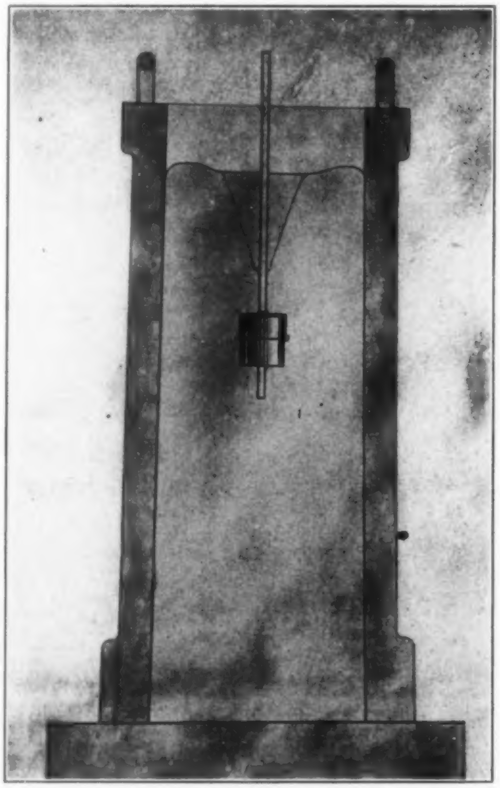


FIG. 18.—STEEL BLOCK WITH BOX OF ANTI-PIPING THERMIT IMMERSED.

FIG. 19.—10-TON STEEL BLOCK AFTER HAVING BEEN TREATED WITH ANTI-PIPING THERMIT.

Conclusion.

While the thermit methods have found a very extended application and rapid development in most European countries, and have also been applied in some foreign countries, especially for making repairs, it is surprising that they have been used in practice to a comparatively very small extent in the United States. While the metals free from carbon, especially pure chromium, have found here a ready market, yet the welding of rails by the thermit process, which should be of the greatest importance to this country has not yet been tried.

This may be due to the fact that the keynote of the industrial development of the United States is specialization, while the thermit methods are of a very manifold nature, as was shown in this article. The production of pure chromium, etc., is of importance for the steel industries. In view of the many uses of manganese, free from carbon, the thermit process should become equally important for the manufacture of alloys of copper, nickel and bronzes. But besides these metallurgical applications, the thermit process is useful in various mechanical operations, for making repairs of all kinds, for instance, in railroad repair shops, in machine factories, and especially in the navy. The field of welding wrought-iron tubes may be considered again as a separate one. Finally, by the use of anti-piping thermit for improving castings, a further successful field has been opened.

On account of these reasons the introduction of thermit and its applications has been behindhand in the United States. The author hopes, however, to be shortly in a position of establishing a suitable organization in this country which will enable the introduction of the various applications of thermit into general use. In view of the engineering talents of the American people, it may be expected that the thermit methods will find a special wide application in this country after a suitable beginning has once been made.

NOTES ON A CLASSIFICATION OF ELECTROCHEMISTRY.

By Clinton Paul Townsend.

(*Concluded from page 379.*)

Aqueous Bath Pigments, White Lead.

The pigment processes, including the production of white lead, are essentially cyclical in character, the pigment being usually derived from the anode by its solution and subsequent precipitation, as oxid, hydroxid, sulfid, carbonate, neutral or basic, chromate, etc. Consequently, in theory at least, the process may continue indefinitely provided the bath be suitably supplied with water and the radical of the precipitant. Since this cyclical character is quite generally characteristic of electrolytic methods which yield insoluble products, it is feasible to group all such under this title. The great number of suggested methods for the electrolytic production of white lead renders it advisable to segregate them.

Aqueous Bath, Platinum and Palladium.

Protective coatings of these metals are frequently applied, the palladium coating being found particularly suited for reflecting surfaces. The electrolytic methods for the production of platinum black are well known, as also the peculiar solvent effect upon platinum of the alternating current in certain electrolytes.

Aqueous Bath, Reduction by Couple.

This title covers the application of the couple for purposes of reduction, the principal technical use being the separation of gold from extremely dilute solutions; in such cases the couple is commonly arranged as a filter. The use of the couple for organic reductions is also common. The term is here given its widest significance.

Aqueous Bath, Refining Metals.

The sub-division of this, the most important technical application of electrolysis, may be extended as desired. Copper, silver and gold are now electrolytically refined in this country, and carefully elaborated methods have been described which are applicable to nickel, lead, tin, antimony, zinc, bismuth, and even iron. At the present time attention is being chiefly devoted to the parting of nickel and copper from bessemerized matte or composite metal.

Aqueous Bath, Refining Metals, Regenerating Electrolyte.

The regeneration methods are not necessarily electrolytic, but relate to the purification of the electrolyte, and generally to the elimination of arsenic from copper refining solutions.

Aqueous Bath, Silver.

The disposition of the metal, voltameter constructions, etc.

Aqueous Bath, Sulfates.

The electrolytic methods relating to sulfates comprise the purification of sulfuric acid, the electrolytic oxidation of sulfur and sulfurous acid, and the production of persulfates.

Aqueous Bath, Tin, Treating Tin Scrap.

The deposition of the metal is, in a commercial sense, quite overshadowed by the recurrent proposition to recover the metal from tinned scrap. The patent and other literature relating to this subject is extended, and recent methods offer promises of commercial success.

Aqueous Bath, Zinc.

Under this title are included the efforts toward electrolytic "galvanizing" of iron; the study of the problem of sponge; the electrolytic behavior of chlorid solutions which offer important advantages for the separation of the metal from ores, and the reversal of certain primary cells.

Asymmetric Cells.

The "electrical valve action" of cells having an electrode of aluminum, and its application to the rectification of alternating currents. These cells employ both aqueous and molten electrolytes.

Carbon.

The conversion of carbon at high temperatures into graphite and crystalline forms is appropriately classified with electric furnace methods. There remains, however, an interesting literature of which examples are the researches upon carbonaceous deposits from aqueous solution, and the subject of the carbon cell.

Depolarizing.

Depolarization is either chemical or mechanical, and includes all methods and devices for removing gases from the electrodes, whether by causing them to enter into chemical combination, as in the oxidation of hydrogen by copper oxid, or by detaching them by the movement of the electrode or electrolyte or other mechanical means or by the diminution of the gas pressure above the electrolyte.

Diaphragms.

The character and composition of a diaphragm is often so closely related to the function to be performed that it is of interest only in connection with a particular method, and is best classified therewith. In the majority of cases, however, descriptions of diaphragms are with advantage cross referenced to the present title, always with a note regarding the purpose for which they are used.

Electric Furnaces.

The class of electric furnaces includes those constructions whose primary purpose is to subject materials to heat developed by means of the current, the constructions wherein the heat development is supplementary to the electrolytic effect being referred to the title "fused bath." The temperature is usually but not always high, the facility of regulation being an advantage of electric heaters no less important than their capability of affording high temperatures. It is usual to distinguish these furnaces as arc and incandescent, and to further subdivide the latter class according to whether the heat development occurs in the charge or product, or in a resistance body in proximity thereto. Such classification is often serviceable, but since this class deals exclusively with structures, which may be capable of several modes of operation in accordance with the position of the electrodes, the character of the charge, etc., it is of little value in this connection. The class deals largely with the more generalized structures, the furnaces intended for a specific purpose, as the production of carbids, of graphite, of phosphorus, etc., being classified with the corresponding methods.

Electric Furnace Processes.

These processes depend upon the heat effect of the current and include reactions which are rendered possible by simple rise of temperature, as distinguished from those in which the electrolytic effect governs. This distinction is in the main a sharp one, although certain methods, as in the production of phosphorous, fall into both classes, the element being in certain cases evolved by the electrolysis of molten phosphides, although in general distilled from a charge containing carbon.

The titles of the several subclasses, defining each by its product, are so distinctive as to require no comment. In a general way they represent the commercial applications of the electric furnace, or those applications which possess a distinct literature. The residual class, however, is a large one, and includes such important applications as the fusion and volatilization of metals and compounds, the production of glass, the formation of compounds containing oxygen by reaction with metal vapors, the production of borides, selenides, etc. Under the subclass "diamonds" may be included not only the theoretically interesting researches relating directly to this subject, but such methods as that of Maxim for the production of hard forms of carbon, and the observations of Ludwig on the behavior of carbon under conditions of extreme pressure and temperature.

Fused Bath.

In the processes which depend upon the electrolytic decom-

position of a molten electrolyte, it is usually essential to develop the heat necessary for the fusion by means of the current itself. This internal heat development possesses the very important advantage of permitting an efficient protection of the containing vessel, either by means of a suitable refractory lining or by a crust of the solidified electrolyte. For constructions of this kind, in which the current performs a double function, the very appropriate name "electrolytic furnace" is now widely used. In certain cases, however, it is still economical to apply heat externally to effect the fusion, so that it is desirable to use here the broader term "fused bath," and to segregate therefrom the two great industrial applications depending, respectively, upon the separation of aluminum and of sodium. The residual class is varied and important, the literature touching the majority of the metals and a wide range of ores and even extending into the organic field.

Fused Bath, Aluminum.

For the sake of unifying and completing this important subject, the methods of purifying bauxite, of preparing alumina for use, and similarly related matters are included with the electrolytic separation of the metal.

Fused Bath, Sodium.

The recent great development of a commercial method for the preparation of caustic soda from lead-sodium alloys produced from fused electrolytes, renders it advisable to construe this title as covering the production of the metal, its alloys and compounds.

Electrolysis Influenced by Magnetism.

The properties of iron electro-deposited in a magnetic field have been carefully studied, as have also the variations in character and distribution of the deposit. In addition, certain technical advantages have been alleged to follow the use of magnetism in conjunction with electrolysis, as, for instance, the amelioration of copper and nickel deposited upon magnetized cathodes and the more rapid oxidation of sodium from mercury-sodium alloys in presence of a magnet. In certain cases also a purely mechanical effect is obtained, as when iron articles are supported by magnets in the plating bath, or the circulation of a mercury cathode is accomplished by means of a magnetic field. The abundant literature of electrolytic conduction without electrodes may also be classified under this title.

Ozone.

The production and application of ozone. The methods depend upon the use of the high tension discharge, and the electrolytic decomposition of certain solutions, particularly such as contain highly oxidized compounds. The ozonizers using the silent discharge are practical and their construction has reached a highly developed state, although, of course, the actual efficiency is low.

Printing Processes.

"Printing with ink," as it is generally called, usually consists in the topical development of a color by means of the oxidizing or reducing action of the current upon a suitable compound saturating the paper or fabric, and usually employed in conjunction with an electrolyte capable of furnishing hydrogen and oxygen at the respective electrodes. As will be obvious, there is no distinction in kind between printing and dyeing methods operated according to this principle, the effect depending merely upon the use of type or an appropriate stencil for the electrode and the selection of a compound to give the color desired. In some cases the metal of the electrode enters into the compound, this modification being obviously undesirable. An extension of the principle leads to the water marking of paper, or to the water-proofing of fabrics by the incorporation therewith of electrolytically produced oxids. Totally different methods are those which depend upon the electrolytic production of printing surfaces for planographic work, certain electro-deposits, and particularly zinc, having been found eminently suitable for this purpose.

Purifying Liquids.

The purification of water by means of soluble anodes capable of yielding insoluble hydroxids, iron, zinc and aluminum, being examples, is rapid and complete, and possesses the advantage over most chemical methods that after separation of the coagulant no extraneous substance remains. In addition, a sterilizing effect due to the current has been alleged. The use of a high tension discharge, and of injected ozone, for the purpose of sterilizing, have often been suggested, and the latter method has been commercially applied. Similar treatment has been applied to sewage, generally with the addition of brine, in order to develop hypochlorites. Foelsing has also devised electrolytic methods for the clarification of log-wood extracts and tanning solutions. Too often, however, the suggested methods conform to no known scientific principles.

Purifying Liquids, Alcoholic.

The current has been applied in almost every conceivable manner to the treatment of alcoholic liquids, the alleged effect being sometimes to oxidize the aldehydes, sometimes to reduce them, often to sterilize, and occasionally to promote fermentation, and always to improve the flavor and "age" the liquor.

Purifying Liquids, Sugar Solutions.

The success of the Schollmeyer method of treating sugar solutions depends on the use of soluble electrodes of zinc. The electrolytic portion of this method is essentially the same as the application of zinc electrodes for the purification of water, but the soluble electrodes have the further function of preventing inversion of the sucrose, and the neutralization of the organic acids greatly lessens the quantity of lime required. A considerable increase in purity follows the precipitation of the nitrogenous matter. A distinct method, of which many modifications have been suggested, depends upon the employment of a compartmental cell, the sugar solution being separated from a compartment containing water by diaphragms of parchment paper, and the electrodes being so disposed in the liquids as to remove the acid or basic radicals of the contained salts, thereby correspondingly increasing the purity of the solution and eliminating some of its more melassigenic impurities.

Solid Electrolytes.

The suggested uses of pyroelectrolytes relate as yet solely to their heating effect, and this class consists therefore of cross references from electric furnaces.

Solvents Other Than Water.

The literature relating to conductivity of non-aqueous solutions is abundant, but the technical applications are few, although certain plating methods utilize glycerine as a solvent, and Kahlenberg has obtained metallic lithium from solutions in pyridin.

Synthesis, Oxids of Nitrogen.

This class is substantially limited to gas reactions, accomplished usually through the agency of the high tension discharge or the arc between carbon or metal terminals, and includes the elaborate researches of Berthelot, the work of Slosse and others, upon the synthesis of sugars, the production of oxids of chlorin and alleged allotropic modifications of chlorin, the synthesis of acetylene, ammonia, cyanogen, hydrocyanic acid, chlorids of carbon, etc. The synthetic reduction of oxids of nitrogen has assumed such importance as to entitle it to separate classification.

Tanning.

This class includes the electrolytic rapid tanning methods, and also such chrome tanning processes as utilize the reducing effect of electrolytic hydrogen.

Vacuum Deposits.

These serve, as a rule, as a basis for further deposition upon non-conductive bodies, and have been referred to under the

title "Cathodes, Metallizing." The question has, however, been widely studied aside from this application.

Consideration of the foregoing outline will show that the residual class entitled "General Art" is substantially limited to investigations of a general character, the results of which are applicable to the entire field of electrochemistry; and to those investigations which appertain neither to solutions, to molten electrolytes, nor to furnace methods, that is to say, such gas reactions as do not involve synthetic effects and are therefore excluded from the class of "Syntnesis."

STANDARD ELECTRODES.

By WOOLSEY McA. JOHNSON.

In the two preceding articles on electrode potentials, I attempted to explain, first, what electrode potential is, and next, how electrode potential can be measured. This third article will discuss the various standard electrodes from several points of view.

It is an axiom that in the finite world of physics to measure any quantity, we must have both a unit and a zero point. Now, both the unit and the zero point can be varied to suit the particular case in hand, or can be fixed definitely with the idea of a maximum benefit to the measurers.

The unit of potential, the volt, is well fixed as a derivative from the C. G. S. system, and is legally defined as $\frac{1.000}{1.433}$ part of the e. m. f. of the special electrochemical system, the Clark cell.

The zero point, however, is not so well defined and is the subject of much learned discussion, in regard to the point of "absolute potential."

Just as we can take any arbitrary standard in measuring level (e. g. the mean level of the ocean), and in measuring temperature (e. g. the melting point of ice in the Celsius or centigrade scale, and the temperature more or less inconstant made by mixing definite amounts of ice and sodium chloride in the Fahrenheit scale), so we can take any arbitrary standard in the measuring of electrode potential. It is entirely immaterial, as far as we are concerned, whether we place the e. m. f. of the "calomel electrode" at — 0.560, — 0.277 or even — 1.560, so long as we make the proper correction when we change from one scale to another. The question is largely one of convenience to the present and future generation of electrochemists.

There is no great significance in the theoretical deduction that the so-called "drop mercury-electrode" possesses the same potential as its solution, for, whenever two solutions are in contact there also is found the seat of e. m. f.

In the case of measuring temperature, the case is quite different, as we have good theoretical grounds for believing from the coefficient of temperature-change in the volume of gases, in the electrical resistance of metals, and in the heat reactions of chemical change that at — 273° C. or 0° on absolute scale, the molecules are motionless, and therefore possess no kinetic energy.

Theoretically it would be desirable to have an exactly analogous zero point for electrolytic work, *par example*, an electrode that possessed no free energy as regards to its electrolyte. Then the passage of a current in either direction would neither absorb or evolve energy. But, as remarked in the case of the mercury drop-electrode, this would be true for only one electrolyte.

On the other hand, there are several advantages of the so-called hydrogen electrode for convenience in expressing electrochemical data. The hydrogen electrode marks the dividing line between two classes of metals, as follows:

(1) Those that displace hydrogen out of strong mineral acids, as Zn, Fe, Cd, Ni.

(2) Those which do not displace hydrogen out of strong mineral acids, as Cu, Ag, Hg, Au.

It equally well defines the above two classes, by the point of electro-deposition out of acid solution.

Also, when we measure the Casparian overvoltage, we have a line on the reducing power of the cathodic hydrogen, dependent on the nature of the cathode and catholyte. In organic reductions this is of vital importance.

On the other hand, it is true that the hydrogen electrode represents considerable work to produce, and only reaches slowly its true value in alkaline solutions.

From an experimental point of view the hydrogen electrode has but one great advantage over the calomel electrode—it introduces no foreign ions into the solution. Consequently, no chain of indifferent electrolytes is needed between it and the electrode to be tested.

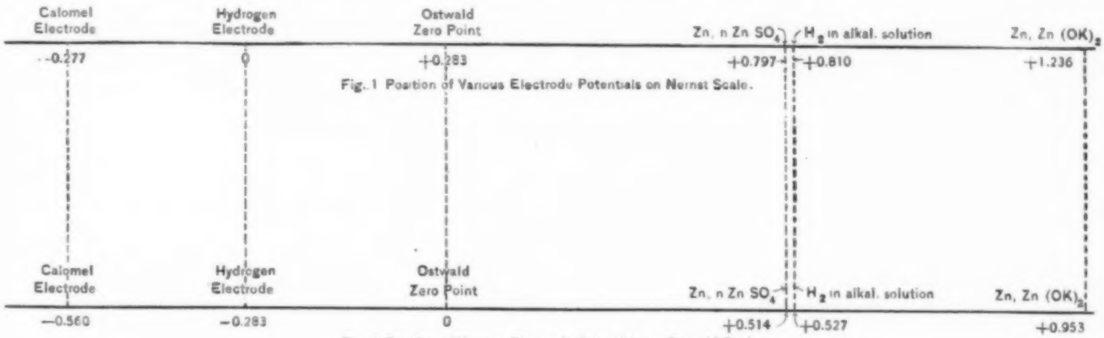


Fig. 1 Position of Various Electrode Potentials on Nernst Scale.

Fig. 2 Position of Various Electrode Potentials on Ostwald Scale.

The so-called "calomel electrode" was fixed at — 0.560 volts some years ago by Prof. Ostwald, of Leipzig. When once made (and it is an easy matter to make one, when the pure materials are at hand), it stays at the true voltage and does not polarize unless many coulombs are taken from it. The current which will polarize seriously the electrode depends on the area of the electrode. As the electrode can be easily made large in area the polarizing current will be correspondingly large. The hydrogen electrode will polarize easily and will recover also with time.

A marked point of superiority of the "calomel electrode" over the hydrogen electrode lies in the difficulty of passing the hydrogen continuously through the purifying solution and thence through the electrode. A small trace of oxygen will combine with the "nascent," or, to be more correct, the "electronic" hydrogen of the hydrogen-platinum alloy of the electrode. This will diminish the electrolytic solution pressure of the hydrogen electrode, so that its potential is not a constant, and it is useless as a standard.

In the case of almost any metallic cathodic-deposition, or of an electro-dissolution of a metallic anode, a test electrode of the same metal, and the same electrolyte as is used in the electrolytic bath is ideal. For theoretical deductions its poten-

tial can be reduced to tnat of hydrogen electrode or Ostwald zero by a simple arithmetical calculation. And the cathode potential which is a measure of the purity of the metal deposited at the cathode can be always measured against the test electrode. Any change from "the initially good conditions" can be read in change from original reading. Concentration changes in the immediate neighborhood of the cathode will be shown by changes in electrode potential of the cathode.

At the anode, similar effects can be studied. If we measure the anode potential, we have a measure of the force which is pulling the different metals into solution. By weighing and analyzing the different slimes, the "sliming effect of the different anode potentials can be determined." In such work, it is essential to have a diaphragm between anolyte and catholyte. The slimes conduct the current fairly well and are very fine. In this condition, they are pulled to the cathode by electrostatic attraction, if by diffusion they come under its influence. Not only do they thus make "warty" deposits, but they contaminate the cathode. If the anode contains precious metals such an action causes a loss in values. This action has, unfortunately, never been studied thoroughly. It is without doubt of utmost importance for practical work. A sharp distinction must always be drawn between "true" electrolytic dissolution and this action, which can be termed "apparent" or false "electro-dissolution."

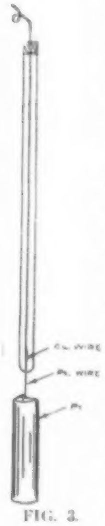


FIG. 3.

No better electrode than this metal-metallic-salt combination can be well imagined, for it does not polarize even at 0.1 ampere per square decimeter, is easy to make and keep constant. Measuring, as it does, the change from "initially good conditions," it can be taken as a special arbitrary zero of electrode potential in each case. For the electrolysis of copper, nickel, iron, cadmium, zinc, lead, silver, etc., a test electrode of this type is most useful.

In storage battery work, the use of the cadmium electrode is almost too well known to require mention. Its aid to the engineer in detecting deteriorated plates is invaluable. This was mentioned in the paper in the July number. For further details the reader is referred to Lamar Lyndon's book, "Storage Battery Engineering." The electrode is not accurate, for the reason that its potential depends on the equilibrium of the equation,

$$Cd + H_2^{\cdot\cdot} + SO_4'' = Cd^{\cdot\cdot} + SO_4'' + H_2$$

as determined by the electrostatic action of the "double layer." This will vary with the density of the acid and nature of the electrode. If the cadmium electrode is dipped in the bottom of the cell at the end of charge, when the acid is concentrated in the bottom, its potential is increased toward the electropositive side of the series. This, of course, is due to the fact that the acid is more dense in the lower part of cell, which can be likewise proved by chemical analysis. It has been a remarkable fact that storage battery engineers gave up after a few unsuccessful trials the idea of a "top-bottom" circulation. Anyone who has seen the buckling and corrosion on lower plates of the "double-plated" cells, must realize that a more uniform current density would prolong the useful life and increase the capacity of the plates. A uniform current density would be rendered by proper circulation.

For alkaline solutions the zinc-zincate electrode can be recommended. The electrolyte should be a solution of the same alkalinity as used in the electrolytic vat, saturated with zinc. The saturation can be done chemically by shaking up freshly prepared $Zn(OH)_2$ with the electrolyte or electrochemically by putting the zinc as anode in the KOH solution with a porous diaphragm. The e. m. f. of this system against the hydrogen electrode was found to vary slightly with the concentration, and was about 0.405 volts. Wilsmore found the value 1.236 volts against the hydrogen electrode in *acid* solution.

As an example of conversion from one scale to another this is excellent, and we will calculate the various positions graphically in Fig. 1.

The upper scale is based on the normal acid hydrogen electrode, which possesses a potential of + 0.277 volts, against the normal calomel electrode. Accordingly the acid hydrogen electrode is — 0.283 volts, against the Ostwald standard, which places the calomel electrode at — 0.560 volts. On the Nernst zero point scale, based on the hydrogen normal electrode, the system Zn — $N.ZnSO_4$ is about + 0.797 volts. The hydrogen electrode in alkaline solution is + 0.810 volts on the Nernst scale, and the system Zn, $Zn(OH)_2$ is + 1.236 volts on the same scale. The difference 0.426 volts is the difference of potential between zinc and hydrogen in alkaline solution. The value, found by me as about 0.405 volts, is smaller by 0.21 volts. This is due to the fact that I saturated the KOH electrolytically with Zn (which naturally decreased the free energy of the system and thereby diminished the e. m. f.).

In Fig. 2 we see the same voltages transferred to the Ostwald scale.

As both the "calomel" and "hydrogen" electrode are used in experimental work, both will be described in some detail.

The hydrogen electrode consists of a glass tube connected with the electrode to be tested by means of a siphon of rubber or glass tubing, and in which glass tube dips a sheet of platinized platinum; through the glass tube B is passed a stream of hydrogen, by means of the pointed tube. The whole apparatus is best made by a glass blower. The electrode is thus an electrode of platinum-hydrogen alloy. To secure proper dissolving of the hydrogen in the platinum, the platinum must be in the spongy condition.

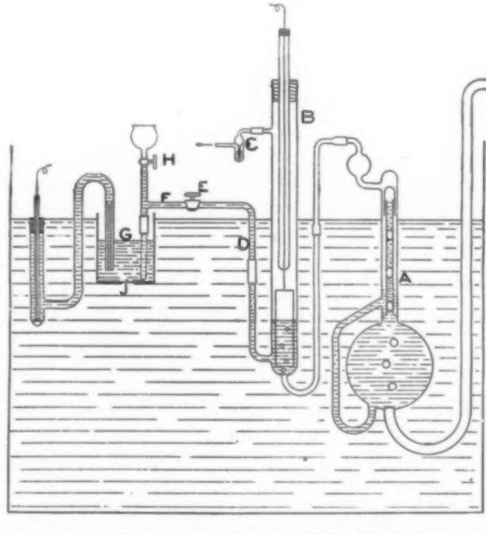


FIG. 4.—HYDROGEN ELECTRODE.

The sheet platinum, 0.1 mm. thick, 4 cms. wide and 5 cms. long, is welded to a platinum wire 0.1 mm. in diameter before a blow-pipe on a small anvil. For details for welding platinum the reader is referred to Ostwald's "Physico-Chemical Measurements." This platinum wire is about 6 cms. long, and is soldered autogenously to a No. 14 copper wire. This soldering is done before a blow-pipe, and is rather hard to perform for the temperature at which the copper alloys with the platinum is above the melting point of the copper. One is very apt to melt the copper wire off. However, by blowing on the flame, just at the moment the alloying takes place, the juncture is cooled and the joint is made. The platinum wire is sealed in a glass tube 15 cms. long, with some glass that sticks to platinum. The top of the tube is sealed with sealing wax. The whole can be seen in Fig. 3.

The platinum sheet is next cleaned from organic matter by heating to white heat in the flame of the blow-pipe, then cleaned by boiling in 5 per cent KOH for thirty minutes, then thirty minutes in 20 per cent HNO_3, and finally boiled for one hour in distilled water. One can be reasonably sure then that the surface is clean.

The platinizing solution should contain about 30 grams Pt. to the liter in the form of acid platinous chloride, the current density should be about 20 amperes per square foot. Dilute solutions make a spongy deposit, but too spongy deposits are not adherent. The addition to the solution just before plating of 0.01 per cent lead acetate helps matters greatly.

Two electrodes are placed in a small beaker filled with this solution as anode and cathode. A reversing switch is included in the circuit. The plating operating is continued for thirty minutes, reversing the current every five minutes. At the end of the electrolysis both the electrodes are platinized, for the operation is not reversible and more platinum is deposited when the electrode is cathode than is dissolved when the electrode is anode. The platinized electrodes should be washed in hot water and then in hot 20-per-cent HNO_3 to dissolve the lead. The electrode thus prepared is set in tube B, Fig. 4, and sealed by means of a parafined cork, bored to receive the small glass tube. The electrode is sealed with sealing wax to preclude any leaking in of air.

Hydrogen made from zinc and sulphuric acid is passed through the electrolyte, as can be seen in Fig. 4. The hydrogen should be washed with alkaline potassium permanganate solution in a Richardson gas-washing-apparatus, then with tne same solution as the electrolyte is a second Richardson gas-washing-apparatus A. C is a small water seal.

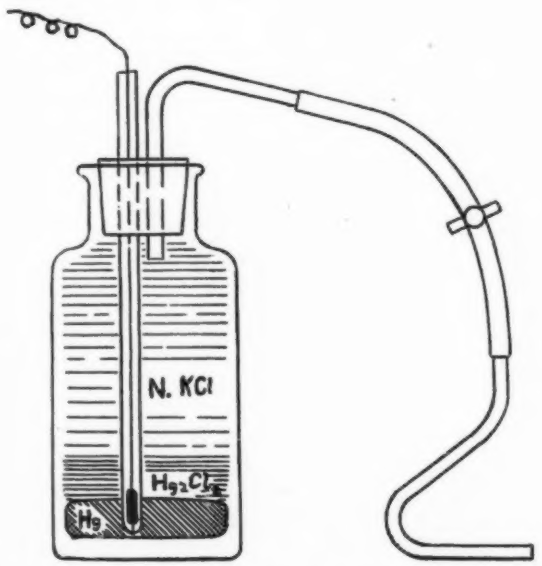


FIG. 5.—OSTWALD CALOMEL ELECTRODE.

The electrode proper should only dip one-third of its height in the electrolyte. The reason for this is that the hydrogen diffuses into the "sponge" above the surface of the liquid much faster than below. The hydrogen occluded above soaks down through the sponge, just as water will soak slowly through a marsh. Finally we reach a point of equilibrium and the hydrogen is at equal pressure all through the electrode.

The "calomel" electrode is easier to prepare and keep constant than the hydrogen electrode. It consists of a glass bottle of 150 cms. capacity. At the bottom of the bottle is a layer of mercury 1 cm. high. The mercury should be chemically pure and should leave no smudge on a porcelain dish when allowed to stand for twenty-four hours exposed to the air. This is a very delicate chemical test. The commercial mercury can be purified by shaking with dilute HNO_3. The mercury is covered with a 2-cm. layer of pure Hg_2Cl_2 calomel—whence the name "calomel-electrode."

Above the calomel completely filling the bottle is the electrolyte, a normal solution of KCl—potassium chloride. The mouth of the bottle is closed with a tightly-fitting rubber stopper through holes in which are passed two glass tubes. One glass tube makes connection with the mercury by means of a sealed platinum wire. The other glass tube makes electrolytic connection by means of a rubber tube to the electrolyte, in which the electrode to be tested dips. Thus, we have a closed electrochemical system, one of whose members we know.

As can be readily imagined, the electrolyte in the vat must not react chemically with the KCl. If it does, a third electrolyte, indifferent to both, must be included in the circuit.

The metal-metallic salt electrode can be made in similar bottle to that used in the "calomel" electrode. Instead of a layer of mercury, a spiral wire can be used. Of course there is no depolarizer needed in this case.

The different conclusions about the various standard electrodes can be summed up as follows:

The advantages of the normal hydrogen-electrode in fixing a line dividing the two classes of metal—base and noble—by their electrolytic pressure, and giving a measure of the chemical potenial of the cathode and catholyte and anode and anolyte, are so great that its use as a zero point in expressing electrochemical data saves much mental labor.

As a work standard, the hydrogen electrodes present too great technical disadvantages.

For most research work the "calomel" electrode is admirable in its constancy and ease of manufacture. Its results can always be reduced to the normal hydrogen standard.

For most practical work with a soluble metallic anode and metallic deposition, a standard electrode of same metal and same electrolyte as is used in the large vat is advantageous for two reasons:

(1) It is easy to make and set up.

(2) It records differences between original electrochemical system, and that set up by the changes on course of electrolysis.

In all the above cases it must be remembered that the measuring instrument or apparatus must be designed with regard to the fact that there is a resistance of several thousands of ohms between the vat and the test electrode due to the small cross-section of the tube of liquid connecting the two.

Often in practical work a metallic test electrode can be dipped directly in the electrolyte, provided there is no chemical action between the two. Then a voltmeter can be employed.

In further articles I will treat the question of electrode potential from the standpoint of the dissociation theory and thermodynamics.

AMERICAN ELECTROCHEMICAL SOCIETY.—At the meeting of the Board of Directors, held in Philadelphia on October 10, the following gentlemen were elected members of the Society: Paul J. Kruesi, Chattanooga, Tenn.; Sherard Cowper-Coles, London, England; W. A. Johnston, Princes Bay, N. Y.; I. A. H. Glenck, Riga, Russia; R. N. Kofoid, Niagara Falls, N. Y.; J. F. Merrill, Salt Lake City, Utah; C. E. Finney, New York; R. H. Aiken, Sault Ste. Marie, Mich.; Joseph Bijur, New York; H. T. Darlington, Philadelphia, Pa.

ERRATUM.—The biographical sketch of Mr. Charles S. Bradley, published in our September issue, contains an error in the date of one of the patents discussed. The second patent granted to Mr. Bradley for an improvement of his bromide battery is No. 409,448, of August 20, 1889 (instead of February 24, 1885). His first patent for this battery is No. 312,802, of February 24, 1885.

HISTORICAL SKETCH OF THE DEVELOPMENT IN THE PRODUCTION OF COPPER, NICKEL AND ZINC FROM CHLORIDE SOLUTIONS.

By William Koehler.

The idea tending toward the utilization of chloride solutions in the electrochemical production of metals seems to have had its inception with Body, who, in January, 1886, applied for the first patent in this direction. The purely metallurgical chemical engineering art had, up to this date, long known the utilization of iron salts, especially the oxidation, reduction and solvent powers of its respective sulphates and chlorides. Body's process and apparatus may be looked upon as the forerunner of the Siemens-Halske and the Hoepfner processes. Body's process did not limit itself to copper, but embraces all metals capable of solution and subsequent precipitation. In carrying out the process Body employed a vessel built up of concrete or Portland cement, covered with a water-proof paint or coating. The adjoining diagram gives an idea of Body's electrolytic bath.

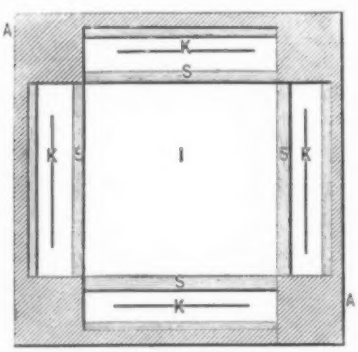


FIG. 1a.—BODY CELL.

A is a cement or concrete vessel, S are partition walls extending half-way down to the carbon bottom C. F are diaphragms of felt cloth, enclosing the space between S and C, K the cathodes, R a stirrer, O the inlet for electrolyte, O′ the outlet for electrolyte.

The electrolyte used consisted of a ferric salt in conjunction with sodium chloride. The ore from which the metal was to be extracted and precipitated was previously saturated with the electrolyte and thoroughly worked over, and was then placed in compartment I, and during the time of electrolysis kept in motion by means of the mechanical agitator R. The electrolyte entered the bath through the opening O in the central compartment, took the course as indicated by the arrows over the partition walls through the cathode compartments past the cathodes K, and left the bath through the opening O′ at the bottom of the cathode compartments. During the passage of the electrolyte in the described course, the following reactions take place:

1st. The metals contained in the ore are brought into solution through the reduction of ferric salts to ferrous salts.

2nd. The dissolved metal is plated out upon the cathodes.

3rd. The chlorine generated at the anode C oxidizes the ferrous salts back to ferric salts. The chlorine evolved but not used in this oxidation acts directly in the nascent state upon the ore or metal which is in direct contact with the anode plate.

At about this time the late Dr. Hoepfner, who had been in the employ of the Siemens & Halske Co., of Berlin, conceived the idea of using cupric chloride instead of the ferric chloride employed by Body and ferric sulphate used in the Siemens & Halske process as lixiviant electrolyte. Hoepfner's original process was patented in 1888. The process as described by Dr. Hoepfner, according to a report made to the Oberschlesische Bezirksverein für Angewandte Chemie, is as follows: Electrolytic baths are employed which are separated through suitable diaphragms into anode and cathode compartments, and allow an independent circulation from anode to anode, and cathode to cathode compartments in any desirable series or number. In the anode compartments are placed insoluble anodes generally formed from gas retort carbon, in the cathode compartments sheets of pure copper. A solution of perfectly reduced cuprous chloride in a salt or calcium chloride solution passes the anodes, and a similar one passes the cathodes.

At the cathodes metallic copper is plated out at a rate of 2.36 grams per ampere hour, exactly double the quantity as precipitated from an oxide salt of copper, such as copper sulphate, from which 1.18 grams are deposited per ampere-hour. At the anode, in case no cuprous chloride is present, chlorine will be liberated and a potential difference of 1.8 volts will be necessary to effect the dissociation, but as cuprous chloride is always present at the anode, the chlorine ions react with cuprous chloride and the formation of cupric chloride results. This oxidation, corresponding to an evolution of energy, produces an e. m. f. which amounts to about one volt, and in the same direction as the working current, so that it aids the electrolytic deposition and reduces the power necessary to plate out the copper. The electrolysis practically proceeds at a potential difference of 0.8 volts, at the terminals of the cell. The cathode electrolyte passing the cathodes has its copper contents precipitated and eventually becomes free from copper. It is then withdrawn from the series of baths to be later taken up in the cycle for the purpose of restoring the original solution volume. The anode solution retains its original contents, but at the end of the operation the copper no longer exists as cuprous chloride, but is completely oxidized to the cupric condition and flows from the baths as cupric chloride. The anode solution is now in condition to extract more metal, and is therefore treated with finely ground ores or matte, and the copper, silver and other metallic constituents are extracted therefrom. For this purpose special revolving leaching drums are employed which have a capacity approximating 10 cubic meters, and afford excellent stirring and agitating facilities. With sulphide ores the following reactions take place:

$$CuS + CuCl_2 = Cu_2Cl_2 + S$$
$$Ag_2S + 2CuCl_2 = Cu_2Cl_2 + 2AgCl + S$$

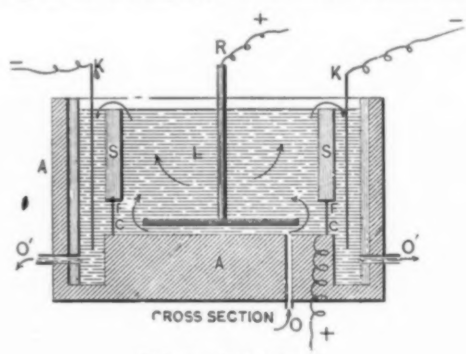


FIG. 1b.—BODY CELL.

Accordingly, cupric chloride, through treatment with copper sulphide, is reduced to cuprous chloride and sulphur separates. Silver sulphide is converted into silver chloride, and, being soluble in the chloride solution, is taken up. The regenerated cuprous chloride which has been clarified, and, as later described, freed from silver, arsenic, bismuth and all such impurities which would contaminate the copper, after being mixed with the cathode solution from above, is then allowed to circulate in two separate portions, one through the anode and the other through the cathode compartments. At the anodes cupric chloride is regenerated, while at the cathodes copper is deposited.

The purifying of the solution is best accomplished through direct chemical means, employing copper oxide, caustic lime or alkali, whereby arsenic, antimony and bismuth, which have a decided deleterious effect upon the deposited copper, are removed. Silver is either chemically removed by means of copper shot, potassium iodide, etc., or electrolytically before the copper. By means of caustic lime the iron which had been

taken up is also removed. If this was not removed, the iron contents of the electrolyte, and incidentally of the lixiviant, would gradually increase to such an extent that the solvent of the original lixiviant would be reduced to about one-quarter of its value. The quantity of copper precipitated by a mechanical horse-power (taking 730 volt-amperes for twenty-four hours at a potential difference of 0.8 volts, including 10 per cent loss of current) is approximately 43 kg. (theoretically 46.4 kg.) In view of the fact that in larger power plants only 22 kg. of coal are required per horse-power-day, we find that with an economical management 1 kg. of coal suffices to produce about 2 kg. of electrolytic copper. Taking into account 1 kg. coal addition for ore grinding, leaching, pumping, etc., we have the production of 1 kg. of copper to the expenditure of 1 kg. coal. This makes it possible to extract copper even in districts where fuel is scarce. The following economical advantages of the described process were claimed by Dr. Hoepfner:

First. Greater capable effect of the electric current, 2.36 grams per ampere-hour of copper being precipitated from cuprous chloride, as against 1.18 grams per ampere-hour from a copper sulphate solution. On account of this feature, the installation cost is reduced one-half.

Second. The greater capability of chloride solutions, compared with sulphate solutions, of dissolving all the valuable metallic constituents contained in the raw ore.

Third. The high concentration of the solution, chloride solutions being capable of taking up 150 grams of copper per liter. In consequence thereof the leaching department requires less space and mechanical energy as against a sulphate leaching plant. Dr. Hoepfner concludes this report with the words: "Notwithstanding that I may say the above-described process has been practically proven, it is still possible that the same may undergo many changes and improvements by which the cost of producing copper will still further be reduced."

The hopes as entertained by Dr. Hoepfner at that time did not mature, although the process was exploited at the Schwarzenberg Refinery in the Saechsische Erzgebirge and at Weidenau-Siegen in Westfalen. The obstacles preventing the successful operation of the process, and which have since been overcome or brought to a state of commercial applicability, may be summed up as follows: First, in order to effect a complete extraction, a fine grinding of the ore or furnace product is necessary; the cost of such grinding is in many cases prohibitive. Second, as it is necessary in some instances to apply external heat in the leaching process, a solution of the iron and other undesirable compounds is unavoidable; this fouls the solution and also lessens the solvent action of cupric chloride. Third, filtering and washing residues is a difficult problem. Fourth, suitable anode and diaphragm materials.

At the present time the anode question may be considered as solved. The Acheson Graphite Co., of Niagara Falls, N. Y., are producing a graphite carbon which withstands the action of nascent chlorine as also copper chloride in an exceedingly satisfactory manner. The diaphragm problem seems to have been solved to a certain extent by the interesting researches of Cohen. This chemist noticed in the electrolysis of a cuprous chloride solution at a low current density that the cupric chloride produced at the anode formed a specifically heavier solution than the cuprous chloride electrolyte. On account of its greater specific weight, cupric chloride sinks to the bottom of the vats and forms a separate and distinct layer which constantly increases in volume, displacing mechanically the cuprous chloride electrolyte. By means of the apparatus as shown in Fig. 2 the deposition of copper was effected without the use of a diaphragm, and at a potential difference of less than one-half volt. This gives an output of approximately 74 kg. (163 pounds) per electrical horse-power day, allowing 10 per cent loss in current.

During 1892 the Hoepfner process was further exploited at the electrolytic bismuth refinery of Mr. George Throm, Giessen, Germany, upon copper and nickel bearing materials, the object being to devise a method for the economic separation of copper from nickel with the ultimate end of producing pure copper and nickel from mixed ores or furnace products.

At this same time the production of zinc, together with chlorine gas and bleach was being thoroughly tested along experimental lines by Dr. George Wannschaff at the Hoffmann Co., Eiserfeld-Siegen, under the jurisdiction of Mr. G. Menne. The process as applied to copper and nickel-bearing material is similar to the extraction of copper alone, and may be described as follows: Copper-nickel ores, matte or furnace products after being ground to 60 mesh were subjected to a leaching process with a solution of cupric chloride containing from 50 to 75 grams of copper per liter. This leaching was effected in revolving drums of about 5 cubic meters capacity. The solution, after being thoroughly reduced, was allowed to cool and clarify, and after removing the small amount of

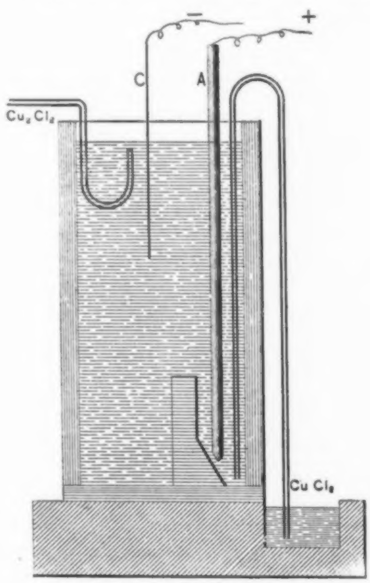


FIG. 2.—APPARATUS OF COHEN.

silver which it contained through precipitation with metallic copper was subjected to electrolysis.

The reactions taking place during leaching are:

(1) $CuS + CuCl_2 = Cu_2Cl_2 + S$

(2) $NiS + 2CuCl_2 = Cu_2Cl_2 + NiCl_2 + S$

(3) $Ag_2S + 2CuCl_2 = 2AgCl + Cu_2Cl_2 + S$

Iron, gold, lead, cobalt, zinc, etc., also go into solution if present in the raw material. The electrolyte consists, after purification, of cuprous chloride and nickel chloride dissolved in a solution of salt or calcium chloride. This electrolyte was then conveyed to double compartment baths in two separate channels, one going to the anodes and the other going to the cathodes. The cathode solution upon flowing past sufficient cathodes lost its copper, while the anode solution, through the action of the chlorine ions, was oxidized back to cupric chloride. The anode solution coming from the baths was again utilized to dissolve more metal from the mattes or ores.

The cathode solution after being deprived of its copper contents, consisted of a nickel chloride solution, which, after thorough purification, was again subjected to electrolysis at a proper voltage in baths having closed anode cells containing carbon anodes. The cathodes consisted of revolving sheet-iron discs, upon which the nickel was deposited. The chlorine gas liberated was returned to the leaching department to effect the further decomposition of the copper nickel-bearing raw

material. The reactions taking place during electrolysis are summed up as follows:

(4) $2Cu_2Cl_2 + 2NiCl_2$ + current = $2Cu + NiCl_2$ (at cathode) $+ NiCl_2 + Cu_2Cl_2 + Cl_2$ (at anode)

Secondary reaction at anode $Cu_2Cl_2 + NiCl_2 + Cl_2 = 2CuCl_2 + NiCl_2$

(5) $NiCl_2$ + current = $Ni + Cl_2$

(To be concluded.)

INTERNATIONAL CONGRESS FOR APPLIED CHEMISTRY.

Report of the Proceedings of Section X.
(Electrochemistry and Physical Chemistry.)
By H. Danneel, Ph. D., and J. K. Clement.
(Continued from page 512.)

Meeting on June 4, Afternoon.
Tests and Analysis of Carbides.

In a paper on this subject Mr. Gall recommended the acceptance of the proposals of the German Acetylene Society. He then spoke about the determination of sulphur and phosphorous in carbides. On dissolving carbide in a large quantity of water all the sulphur present remains in the milk of lime, and it can be determined as $BaSO_4$. Phosphorous, on the other hand, passes over quantitatively into the gas. It is therefore necessary to fuse the carbide with $NaNO_3$. The phosphorous in the residue can then be determined with molybdenum. Speaker gave the results of a series of analyses.

Meeting on June 5, Afternoon.
Electrochemical Units of Measurement.

In a paper on this subject Prof. W. Nernst gave an historical review of the origin of the committee for the establishment of electrochemical units, also the reasons of the committee for establishing for the present only a small number of symbols and for adopting as far as possible the hitherto customary ones. The suggestions of the committee are contained in the following table:

Variables.

p, P Ordinary and osmotic pressure.
v Volume.
T Absolute temperature.
Θ Celsiustemperature.
t Time.
δ Density.
Δ Vapor-density referred to air.
π_0, φ_0, ϑ_0, Critical quantities (pressure, volume, temperature).
π, φ, ϑ Reduced quantities (pressure, volume, temperature).
Q Quantity of heat.
U Internal energy.
a Atomic weight ($O = 16$).
M Molecular weight ($O_2 = 32$).
c Specific heat.
c_p, c_v Specific heat at constant pressure or volume.
$C_p = c_p M$, $C_v = c_v M$ Molecular heat at constant pressure or volume.
N Index of refraction.
κ Conductance in reciprocal ohms per centimeter-cube.
η Concentration (gm.-equivalent per ccm).
$\Lambda = \frac{\kappa}{\eta}$ Equivalent conductivity.
Λ_∞ Equivalent conductivity at infinite dilution.
γ Degree of Dissociation.
K Equilibrium-constant of the law of chemical mass-action.
E Potential-difference.
W Resistance.
I Current-strength.
ϵ Electrode potential, decomposition-potential.
ϵ_h Potential with reference to a normal hydrogen-electrode.
ϵ_c Potential with reference to a normal calomel electrode.

Constants.

R Gas-constant per mol.
A Mechanical Equivalent of Heat 41.98×10^6 erg per gm. cal. at 15°.
F Valence-charge (96,540 coulombs per gm. equivalent).

Abbreviations in Text.

2n. H_2SO_4, etc., for double equivalent sulphuric acid, etc.; $H^{\cdot}$, Cl', $Ba^{\cdot\cdot}$, etc., for singly charged positive H-ion, singly charged negative Cl-ion, doubly charged positive Ba-ion, etc.

In the discussion which followed Prof. Noyes, of Boston, raised the following objections to the suggestions of the committee. First, the incompleteness of the table, since some of the most fundamental quantities used in chemistry are not considered, e. g. mass, energy, work, entropy, force, velocity, acceleration, distance, height, surface, radius, number of mols, reaction-velocity, and solubility. If the system of the committee should be now adopted, it will be more difficult to introduce later a complete and rational system of notation. The whole matter must be taken into consideration at one time; to adopt a notation for a few quantities, and to leave many others, some of which are still more important, to further agreement or arbitrary selection, is as unsatisfactory as it would have been for chemists to adopt first symbols for the metallic elements (for example, N for sodium [natrium], C for calcium) while leaving the non-metallic elements temporarily unprovided for (thus precluding the use of N for nitrogen, and C for carbon). His second objection was that the proposed notations are not rational or systematic, not being based on any general principles. Noyes proposes to designate all electrical quantities by a certain style of type, e. g. small capitals, optical quantities by a certain other style, such as Greek letters, and specific properties by underlining the letter representing the general properties, for example, V = volume in general, $\underline{V}$ = specific volume. His third objection was that the matter ought to be considered by an international committee before accepting it, in order that full justice may be done to the usages of different countries. Noyes suggested that the Section X. recommend to the Congress the appointment of such a committee to consist of five members. To show how the matter could be arranged, Noyes presented the table which he used in his book.

Dr. Nernst replied that with such a revolutionary procedure as Noyes suggested it would be impossible to bring the suggestions into general use, as the force of habit is too great to be overcome by the best and most complete system. Nernst agreed to the appointment of an international committee, but in his opinion this did not prevent the acceptance of the report of the commission.

The motion of the committee to recommend to the Congress the acceptance of the above system of notation was then unanimously carried. Noyes' amendment was rejected, although Nernst and the great majority of the other German professors and instructors present were in favor of it. In the opinion of the reporters (Danneel and Clement), the question to be voted upon was not sufficiently clearly stated. Moreover, the attitude of Section X. in rejecting the amendment was afterwards redeemed by the entire Congress, which complied with Noyes' suggestion and appointed a committee.

The report of the committee appointed by the Congress of 1900 to establish uniform symbols for the fundamental electrochemical quantities was then presented by Prof. Marie of Paris, who gave a review of the various suggestions which had been submitted to the committee and joined in the suggestions of Nernst.

The remaining papers of Session IV. were physico-chemical and not electrochemical. Prof. Schenck, of Marburg, spoke

on the dissociation of carbon monoxide. He had measured the equilibrium and the order of the reaction $2CO = C + CO_2$, in the presence of various metals. Nickel and cobalt act as catalytic agents and accelerate the reaction. Iron participates in the reaction according to the equation $2Fe + 3CO_2 = Fe_2O_3 + 3CO$, as long as the carbon dioxide pressure remains above a certain value. Below this pressure iron acts only as a catalytic agent. The author makes from his experiments certain deductions concerning the order of the reaction, at low temperatures (310°) the reaction is monomolecular, at higher temperatures (510°) bi-molecular.

In the discussion BODENSTEIN called attention to the fact that one must be cautious in drawing conclusions concerning the order of such a reaction because, in the first place, on account of too little diffusion very often a different equilibrium sets in near the catalytic agent than the one measured, and secondly there is danger that, on account of the great "heat effect" of the reaction, local rises of temperature may occur so that the temperature is not uniform.

VARIATION OF ELECTRIC RESISTANCE UNDER THE INFLUENCE OF LIGHT.

A paper on this subject was read by L. ANCEL. Due to the great change of resistance which it undergoes under the influence of light, selenium has become very important for telephotography. It is very expensive and is injured by the action of extra currents. Soot, tellurium and thin leaves of various metals undergo a similar change of resistance under the influence of light, but are not sensitive enough. Selenium covered with soot is more sensitive than selenium alone, and is free from the defects which are peculiar to the latter.

(*To be concluded.*)

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

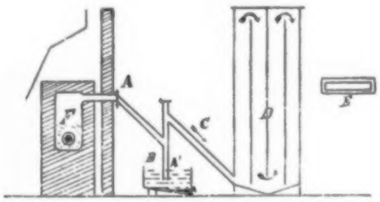
A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

By CARL HERING.

Industrial Electrolysis of Water.—The production of hydrogen and oxygen, though one of the oldest electrochemical experiments, and proposed in a large number of patents, has been carried out industrially only to a limited extent. There was considerable difficulty in developing the laboratory apparatus so that it would operate successfully in practice, one of the hardest conditions to meet being the necessity of absolute safety of operation, and this required the exclusion of every possibility of the formation of an explosive gas mixture. Another difficult matter was the necessity of providing a material for the electrodes, which is not at all or only slightly attacked by the electrolyte, and the necessity of constructing apparatus with a small internal resistance. In the September number of the *Electrochemische Zeitschrift*, SCHOOP discusses the various processes which have been applied on an industrial scale, and gives data on the employment of hydrogen and oxygen for soldering purposes. The principal processes used in practice are those of Garuti, Schmidt and Schoop. In the first two the electrolyte is an alkali, and in the last an acid. Garuti's process depends on a metallic diaphragm, the lower part of which is perforated, thereby permitting free communication of the liquids in the different compartments of the apparatus, but preventing a mixture of the gases as long as the gas pressure does not go above a certain limit. If this is not carefully regulated, however, the formation of an explosive mixture of gas can easily take place. It is absolutely necessary not to go above 3.4 volts for the pressure of the bath, in order to prevent the metallic diaphragms from becoming bipolar electrodes. The electrodes are of iron, and the anodes are slowly decomposed and have to be renewed every two or three years. The caustic soda solution takes up carbonic acid from the air, which has the effect of decreasing its conductivity. The apparatus of Schmidt looks somewhat like a filterpress, and consists essentially of bipolar, iron electrodes, connected in series. Asbestos cloths are used as insulators and for packing, and also for the separation of the gases. One side of each electrode communicates with a canal, which serves for leading off the hydrogen, while the oxygen passes through a similar canal at the other side of the electrode. The apparatus has to be taken apart and cleaned every six weeks and the asbestos diaphragms have to be renewed from time to time. The apparatus constructed by Schoop is not very clearly described, and is not illustrated. Its chief feature seems to be the use of a tubular form of the electrode, which is enlarged at its lower end to the shape of a bell. The electrode material is of lead in the form of a pipe, surrounded on the outside by insulating material; the tubes are connected in parallel in groups of 2, 4, 6, 8, etc. To increase the surface which receives current, a body of lead of star-shaped cross-section is cast inside of the electrodes. One such tube can carry 25 amperes continuously, and there are then set free 5.22 liters of oxygen and 10.44 liters of hydrogen per hour. The voltage for each cell is 3.3 to 3.6. After running some time the cell is similar to a storage cell of small capacity in consequence of the formation of lead peroxide on the positive electrode. With a 110 volt plant there can be 30 of them connected in series. In order to prevent current from the cells being returned to the circuit, a circuit breaker has to be provided. The gases are lead off from the tops of these tubes and the use of diaphragms is thereby entirely done away with, and therefore the formation of explosive mixtures is prevented absolutely. The pressure under which the gases are generated depends upon the length of the lead electrodes, and may be chosen at will within certain limits. In the apparatus as used in practice, the pressure amounts to 60 to 70 cm. head of water, so that no further compression is necessary and the gases can be conducted directly to the oxyhydrogen burners. Extended experiments are said to have demonstrated that 1 e.hp.-hour furnishes 48.75 liters of oxygen and 97.5 liters of hydrogen, that is, an expenditure of energy of 6.2 to 6.8 hp-hours has to be made for one cubic meter of detonating gas. The gases are pure, but the oxygen is strongly mixed with ozone, which cannot be prevented with an acid electrolyte. The utilization of hydrogen and oxygen forms the subject of the second part of the article, the author enumerating the application for therapeutic purposes, for soldering and welding of various precious and other metals, for aeronautics, for the manufacture of glass, and for illuminating purposes. The application of the gases to soldering and welding is described at some length and is illustrated. For most of the work of this kind, there are required one part of oxygen to four parts of hydrogen, instead of one part of oxygen to two parts of hydrogen, as it is preferable to give the flame reducing properties, and as the oxygen of the air also takes part in the combustion. The great advantage of welding with the oxyhydrogen flame consists in the possibility of performing a so-called autogenous weld, that is, without the use of a solder. It has been found in practice that for the sake of safety the gases can be mixed only when close to the point where they are burned. It is, however, possible to conduct detonating

gas to the soldering blow-pipe, but there is then always a possibility of the flame striking back. In either case it is of the utmost importance that the velocity with which the gases emerge from the burner should be greater than the velocity with which the flame of the detonating gas propagates itself. Two recent constructions of oxyhydrogen burners are diagramatically illustrated. The soldering of aluminium is said to be easily accomplished with the oxyhydrogen flame, as also the soldering of sheets of iron, copper and brass.

Extraction of Mercury in the Electric Furnace.—The advantages of the electric furnace for the extraction of mercury from its ores are briefly set forth by BECKER, in an article in *L'Industrie Electrochimique*, September. The ordinary distillation process is first reviewed. If a charge of mercury ore and lime is introduced into the electric furnace and heated, the mercury is entirely distilled off and the discharge of the furnace can be performed without danger. The use of an electric furnace also does away with the cumbersome retorts, and the charging of the furnace can easily be made a continuous operation. The openings by which the electrodes enter into the furnace must not communicate with the atmosphere, but must be provided with cylinders or tubes, in which the electrodes can slide. The system of electrode construction resembles that adopted as early as 1886 by the Cowles Brothers for their aluminium bronze furnaces. The accompany figure gives a schematic representation of an industrial installation.



EXTRACTION OF MERCURY IN THE ELECTRIC FURNACE.

The furnace F is placed under a hood, provided with an air-draft. The tube A, through which the vapors escape, is formed of two iron tubes placed inside of each other, as indicated at E; a current of cold water circulates between them. The mercury which condenses in the tube A runs into the vessel B, which is filled with water. The uncondensed vapors pass through the tube C into the condensation chamber D. For each part of mercury in the ore it is necessary to add two parts of lime. When the ore carries pyrite, the quantity of lime must be increased. When the quantity of lime is not high enough, sulphide of mercury distills with the mercury, and when the ore is distilled entirely without lime, the whole of the sulphide of mercury distills off. The power required varies with the contents of mercury in the ore and with the nature of the gangue. This process is stated by the author to be applicable also to poor ores which might be charged directly into the furnace after they are pulverized and the necessary amount of lime added, or which might be subjected to a preceding concentration.

Electrothermic Processes for the Production of Metallic Powders.—A brief description of several electric processes for the production of metallic powders is given in *L'Industrie Electrochimique* for September. The Gérard process consists in heating the metals in an electric furnace, which is narrowed down to a small cross-section in the middle. The ends of the electrodes enter the far sides of the furnace at its largest parts. When the furnace is filled with metal the narrow portion of the middle offers the greatest resistance to the path of the current. When the metal, which by preference is melted previously, is introduced into the furnace, it will become hottest in the narrow part of the furnace and will be vaporized there. The metallic vapors are led into a condensation chamber. By blowing air into the furnace at a certain distance above the hearth, the combustion of the metallic vapors can be brought about if desired, and the method is therefore applicable to the production of zinc oxide, tin oxide, etc. Another process, which is briefly described, is applied to the production of oxide of tin. A third process consists in the volatilization of the metal by arcs produced by interrupting a stream of metal which carries the electric current, and introducing a stream of an inert gas or of air if metallic powders or their oxides are required.

Electric Furnaces.—MINET gives in the *Electrochemische Zeitschrift* of September, the continuation of his serial on the electric furnace, its genesis, development and forms of application. Several types of Gérard and Street's constructions are illustrated, as also a furnace of Ducrebet of a well-known form.

Elmore Copper Depositing Process.—A short illustrated description of the well-known Elmore process for the manufacture of copper tubes is given in the *Electrochem. and Metallurgist*, September. The current density of the cathode is stated to be 600 amp. per sq. meter (56 amp. per sq. foot), and the deposition of a copper tube 4 to 5 mm. thick would therefore take just a week. The three Elmore works in Schladern (Germany), Leeds (England), and Havre (France), are stated to have a total weekly capacity of 396,000 pounds of copper. The English and French works use steam exclusively, while the German works make use of 550 hp from water power and 400 hp from steam. The latter works produce some 2,600,000 pounds of copper per year.

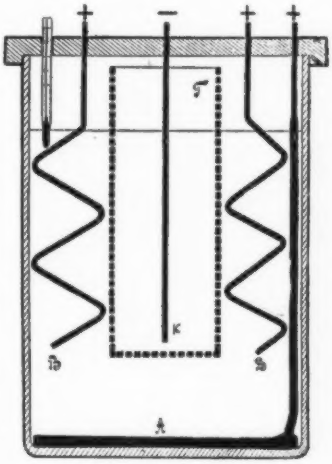
Polishing and Plating of Metals.—The continuation of the extracts from a manual under this title by HAWKINS, which was referred to previously in the Synopsis, is given in the *American Jeweler* of September. The arrangement of plating shops for room and light, are briefly discussed in the first part. The author next deals with the question of dynamos for electroplating, and discusses the series, shunt and compound machines. The machines are considered in some detail, especially in view of the troubles which constantly occur in plating shops and which are due to the ignorance of electroplaters on the subject of electricity. The capacity of machines for the work they have to do, is referred to, and it is mentioned that owing to the absence of ampere-meters in plating shops, no reliable data exists as to the quantity of current necessary for certain classes of work. The tables of amperes per square foot which exist are wholly misleading. They were made by taking, for convenience, thin sheets of metals and measuring the number of amperes per square foot which could be used for deposition without burning the deposit. He states that they are correct as applied to that sheet, but the mistake was made of supposing that only the surface need be considered. For instance, the tables state that cyanide of copper solutions require six to eight amperes per square foot and acid copper solutions ten to twelve. This, says the author, is true on a sheet of twenty-two gauge, but a plate half an inch thick will take twenty to twenty-seven amperes, and a cast-iron panel three-quarters of an inch thick and four by seven feet in its other dimensions, will require from fifty to sixty amperes per square foot to put the metal on properly in the center without burning at the corners. Twenty amperes per foot is common practice on heavy work where six are indicated in the tables, and nickel-plating direct on sheet zinc will take sixty amperes per foot. A dynamo bought according to the tables will therefore be wholly inadequate for anything but thin metal. The author's explanation as to how the mistake arose is as follows: The limit of quantity of current is at that point at which the metal commences to discolor from the heat evolved when the metal is deposited out of the solution; a thin plate conducts heat slowly beyond a given quantity. On the other hand, a large, heavy piece contains metal enough to conduct the heat away as fast as it is formed, and ten or twelve times as much current may be used profit-

ably on such work. Between this and the thin sheet there are numberless gradations of work which have never been properly measured by anybody. In stating the opinions of Mr. Hawkins, the compiler does not wish it to appear as though he endorsed all of them. The fact that a watt during a whole hour will generate less than a kilogram calory (more accurately, 0.866), will hardly bear out the contention that it is a question of heating, nor that the popular term "burning at the corners" has anything to do with actual burning by means of heat. In the opinion of the compiler, the limit to the permissible current density is due to the exhaustion of the desired ions in a molecular layer next to the electrode, thus making the solution which is in immediate contact with the electrode, very dilute, and since it is only from this molecular layer, which is in actual contact with the electrode, that the ions are deposited, the density of the rest of the solution does not come into consideration. It therefore seems that rapid circulation for quickly replacing this exhausted layer is that which will enable the current density to be increased.

Metallic Deposits by Contact.—Metallic deposits can be produced on metallic objects by using certain electrolytic baths in which the objects are subjected to the action of the bath in contact with zinc, aluminium or magnesium. Darlay, in the *Electrochem. Zeit.,* September, states that no practical result can be gotten in this way, as the baths which were used in connection with aluminium always had an acid character. If such an acid bath is used, the aluminium is attacked, thereby an electric current is generated and a metallic deposit is produced at the surface of the objects to be plated; but this action soon stops, the aluminium is not attacked any more and no more metal is deposited. It is stated that such baths can be used successfully if the acid baths are replaced by others of a strongly alkaline character. Solutions are recommended consisting of a chloride of the metal to be deposited, of ammonium chloride, and of a large excess of an alkaline phosphate or pyrophosphate, with or without the addition of ammonium carbonate. Solutions of a double chloride of ammonium and the metal to be deposited can also be used, with a large excess of alkaline phosphate with or without ammonium carbonate. The following compositions of baths are given: For nickeling, water 25 liters, nickel chloride 500 grams, ammonium chloride 500 grams, sodium pyrophosphate 4 kilograms, and ammonium carbonate 200 grams; or water 10 liters, nickel ammonium chloride 500 grams, sodium pyrophosphate 2 kilograms, and ammonium carbonate 300 grams.

Theoretical and Experimental.

Electrolytic Production of Several Plumbic Salts.—A new method for the production of plumbic chloride is described by Elbs and Nuebling, in the *Zeit. f. Electrochemie,* Sept. 17. The vessel in which the electrolysis is carried out is of glass, and contains a porous cell suspended in it. The apparatus is illustrated in the adjoining figure. A sheet of lead is suspended in the porous cell and serves as cathode. On both sides of the porous cell there are arranged two anodes *B* formed of strips of lead, bent into zig-zag shape; another anode of carbon *A* rests on the bottom of the vessel. The electrolyte in the cathode compartment consists of dilute hydrochloric acid of about 1.1 spec. grav., while the same acid of 1.18 spec. grav. is used as anode liquid. The carbon anode receives about the same amount of current as the two lead anodes, which is controlled by rheostats and ammeters in the two branches of the current. The mean current density at the lead anodes, counting both surfaces, is 0.6 to 0.8 amp. per sq. dm., and at the carbon anode 4 amp. per sq. dm. The temperature of the bath must be below 10° C., and it is therefore cooled with ice on the outside of the vessel. For each liter of anode liquid there are introduced 20 to 25 ampere hours; the yield in plumbic chloride hydrochloric acid H_2PbCl_6, obtained is then 70 to 80 per cent of the theoretical. A further continuation of the electrolysis is stated to be disadvantageous, on account of the rapid decrease in yield, because the acid formed takes part in increasing degree in the electrolysis. During electrolysis only a feeble development of chlorine takes place and the anodic liquid is colored orange yellow. The hydrochloric acid solution of plumbic chloride can be kept in closed bottles for any length of time; in open vessels it slowly but gradually gives off free chlorine with the separation of plumbic chloride. The method of determining the yield of plumbic chloride is briefly outlined by the author, who then gives a description of several double salts of plumbic chloride which they prepared. Ammonium plumbic chloride, pyridene plumbic chloride, and chinolene plumbic chloride are described.

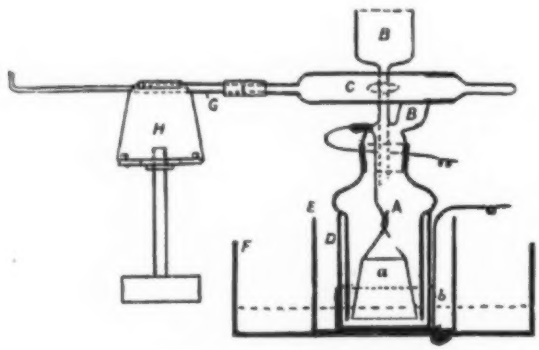


ELECTROLYTIC PRODUCTION OF PLUMBIC SALTS.

The authors then tried hydrobromic acid under the same conditions as were found favorable for the production of lead tetrachloride, with a view to get lead tetrabromide, but they did not succed in getting more than lead dibromide and free bromine. Hydriodic acid was also tried, to see whether they could get lead tetraiodide, but the electrolysis of 1.42 spec. grav. hydriodic acid could never be continued for any length of time, because the resistance increased greatly on account of the formation of a thick layer of lead iodide on the anode. The brown anodic liquor is saturated with lead iodide, which separates on the addition of water. A watery solution of pyridine hydro-iodide produces a grayish green, crystalline precipitate, which finally yields the double salt $2C_5H_5NHI.PbI_2$. The chinolene hydro-iodide furnishes also the corresponding double salt. The authors also tried watery solutions of pure chromic anhydride, free from sulphuric acid as electrolyte. Electrolysis was conducted in a glass vessel with a semi-cylindrical anode of lead, a porous cell and a lead cathode in the latter. The temperature was kept between 15° and 20° C by cooling the vessel on the outside. If the solution of chromic acid is very dilute, as about 0.1 per cent, the lead anode is attacked and chrome yellow is formed, and if the chromic acid content of the electrolyte is kept constant by adding the acid as it is used up, the yield of chrome yellow is nearly quantitative. If the concentration of chromic acid increases to about 1 per cent, a firmly adhering layer of chromate of lead is deposited on the anode, which prevents the passage of the current in a short time. If the contents of chromic acid reach several per cent, the passage of the current is hindered by the chrome yellow formed, but is not prevented, as spots of peroxide of lead appear, at which oxygen is liberated. The more the concentration of chromic acid increases, the more lead peroxide is formed, until the concentration goes beyond 40 or 50 per cent, when the anode slowly becomes soluble again. The authors interpret these results by claiming that in very dilute solutions, plumbous chromate is formed; in moderately dilute solutions, however, a plumbic chromate appears also, which, however, is immediately hydrolytically dissociated with the separation of lead peroxide. The more the concentration increases, the more the production of plumbic chloride is favored and its hydrolytic dissociation prevented, so that a considerable quantity is present in the anode liquid. From then on the instability of the pulmbic chloride leads to its decomposition with the solution of oxygen. The authors give

reactions observed by them, which serve to support this theory. They also tried ortho-phosphoric acid of 1.75 spec. grav. as anode liquid, with dilute phosphoric acid as cathode electrolyte, and they were able to obtain a plumbic salt of the ortho-phosphoric acid, with an anodic current density of about 1 ampere per sq. dm., at the room temperature. With an electrolyte of a 17 to 20 per cent solution of hydrofluosilicic acid and a current density of about 1 ampere per sq. dm., the anode is dissolved without the formation of a precipitate and lead is deposited almost quantitatively at the cathode. No plumbic salt was obtained with an arrangement similar to that used for the production of lead tetrachloride.

Electrolytic Estimation of Minute Quantities of Arsenic.—A method for the electrolytic estimation of minute quantities of arsenic has been worked out by THORPE, and is published in the *Electrochemist and Metallurgist*, September. It is intended more especially for the analysis of brewing materials. The apparatus used is illustrated in the adjoining figure. It consists of a glass vessel *A* which forms with the porous vessel *D* the inner cell for the cathode, where the hydrogen and hydrogen arsenide are produced on passing the current. *A* is open at the bottom and fitted at the top with a ground-glass stopper, through which is passed the stem of a tap-funnel. The glass stopper also carries a bulbed exit tube, connected with the drying tube *C*. The cathode is of platinum and is cone shaped with several perforations. The anode cell consists of a glass vessel *E*, and the anode is a platinum band passing loosely around the porous cell. A constricted tube of hard glass is connected to the drying vessel *C* and supported on the mantel of a small Bunsen burner, *H*. The arsenic is to be deposited in this tube. The methods for preparing the



ELECTROLYTIC ESTIMATION OF ARSENIC.

extracts or solutions of the various substances, such as malt, wort, hops, beer, etc., are given in detail, and the manipulation of the apparatus is described. The reaction depends on the evolution of the arsenic contained in the substance under investigation, and which is introduced into the cathode compartment of the apparatus, as arseniuretted hydrogen and the deposition of a mirror of arsenic in the hard glass tube. These deposits are then compared with similar deposits obtained by the electrolysis of solutions which contained a known amount of arsenic. The advantages of the electrolytic method are as follows: 1, it does away with the use of zinc; 2, it is simple in operation, is under perfect control, and may be carried out under such conditions that the results obtained by different operators are strictly comparable, inasmuch as with a current strength of fair regularity the evolution of the gas is practically constant and uniform; 3, the whole of the solution to be tested for arsenic may be added at once, so that during the whole time of testing the arsenic is under the influence of "nascent" hydrogen; 4, it has been established that such amounts of arsenic as are present in beer or its ingredients are evolved as hydrogen arsenide during the thirty minutes occupied by the test. The nature of the material associated with the arsenic is found to exercise no inhibiting effect on the formation and evolution of the hydrogen arsenide. Aqueous extracts of malt or worts may be added directly to the electrolytic apparatus without previous destruction of the organic material as required by the zinc and acid process; 5, the deposits obtained are more uniform in character than those furnished by the zinc and acid method, and admit therefore of more accurate quantitative comparison.

Double Electric Layer and Absolute Potential.—According to BILLITZER, if a difference of potential is applied at a region where the double layer is present, the ponderomotive forces exerted by the electric field on the two parts of the double layer, are opposite. A relative displacement of the two layers must therefore take place, and this displacement will change direction with the sign of the double layer and will disappear with the latter. Fine metallic wires of 0.01 to 0.05 mm. diameter are fused at their ends so as to form small globules. They are suspended at their other ends from a thread of quartz between two electrodes, between which is established a difference of potential of 220, 158.72, or 10 volts. The displacements of the thread are observed by means of a microscope. He has observed these and similar phenomena and gives the results of his investigations in *Drude's Annalen*, July, 1903, an abstract of which is given in *L'Eclairage Electrique* of September 5. Platinum charged with hydrogen is negative towards solutions which are weakly acid or alkaline; if charged with hydrogen, it is negative towards weakly alkaline solutions and positive towards acid solutions. Solutions which contain ferrous and ferric ions at the same time are well adapted for the determination of the point of inversion. The absolute concentration of the salts has no influence, but only the ratio of the concentrations of the two kinds of ions. The experiment succeeds also with a solution of formaldehyde, of ethyl alcohol and of oxygenated water. The inversion is produced when the difference of potential between the metal dipped into the solution and a calomel normal electrode is in the neighborhood of 0.12 volts. With mercury the inversion is obtained with difficulty on the addition of mercuric nitrate to the solution. Silver dipped into a solution of nitrate of silver of increasing concentration does not give any inversion. Whichever be the metal and the method employed, it is found for platinum, gold, palladium, silver, mercury, copper and iron, that the point of inversion corresponds to a difference of potential of 0.4 volts (towards hydrogen). This result is not modified by the use of complex salts. These results are explainable with difficulty, if the definition of the double layer as given by Helmholtz is adopted; it is particularly difficult to conciliate them with the idea of two layers of opposite sign.

Vaporization and Boiling of Metals.—The vaporization and the boiling of metals in quartz vessels and in the electric furnace at the "vacuum of the cathode light," has been investigated by KRAFFT, and the results are published in the *Berichte der Deutsch. Chem. Ges.*, 36, 1690-1714. An abstract is given in the *Zeit. f. Electrochem.*, September 17. The author used several forms of quartz vessels, the thin-walled ones being used up to 1200° C, the thick-walled ones to 1400° C. For the metal zinc he found a rapid sublimation at 430° C, which continued to an appreciable degree down to 300°. Quick distillation, accompanied by ebullition, took place at 640° C, 5 grams only taking 30 minutes to vaporize; the boiling zinc seemed to show the Leidenfrost phenomenon. Cadmium showed appreciable vaporization as low as 320°, slow distillation at 450°, and ebullition with Leidenfrost phenomenon and rapid distillation at 470° C (about 3 grams in 20 minutes). Selenium was easily volatile at 380°. Tellurium was shown to be appreciably volatile at 430°; strong ebullition and rapid distillation (about 2 grams in 25 minutes) taking place at 540°. With lead, appreciable vaporization showed itself at 800°, strong ebullition at 1160° and distillation of 1.2 grams in about 10 minutes. Tin at 1100° did not show any traces of volatiliza-

tion. Antimony at 670° was appreciably volatile; at 780° rapid distillation showed itself (3.5 grams in about 20 minutes). Bismuth is already volatile at 540°, and 3 grams volatilized in about 15 minutes at 1050°. At 1200° therefore, very closely above the melting point, silver showed appreciable vaporization; at 1340° rapid vaporization took place (0.09 gram in about 12 minutes); ebullition was not reached. Copper showed appreciable volatilization at 1315°, but it was appreciably less than with silver. Gold at 1375° shows appreciable vaporization, but very slowly. The boiling points for the conditions under which the author worked were found to be for zinc about 550°, bismuth about 1000°, antimony about 735°, and lead about 1140°.

Chemical Valency, Electrical Conductivity and Hardness of Metals.—Molecular combinations of electrolytes in solution, which are practically in the gaseous state, according to Vant Hoff's theory as enlarged by Arrhenius, have the same ultimate electric capacity with varying valencies. In an article in the *Electrochemist and Metallurgist*, September, RHODIN extends this law to substances in other forms of aggregation, with special reference to metallic solids. He looks upon the electrical conductivity of a metal as caused by the transfer of electricity from one section of the conductor to another by means of the motion of the molecular combinations of which it is composed. As a consequence of a mathematical investigation, he comes to the conclusion that a hard metal has more complicated molecules than a soft one. To elucidate the difference between metallic conductors and all other substances, he puts down the following criteria: 1. All metallic conductors are composed of ultimate particles, which can act as cations during electrolysis without the intervention of other elements. The ultimate particles are thus electrically uniform. 2. All electrolytic conductors are composed of ultimate particles of two kinds, viz., one or more cations and one or more anions, which readily dissociate by the influence of a solvent or fusion. They are thus electrically binary. 3. All dielectrics are characterized by an exceptional resistance offered by their ultimate particles against molecular motion, depending upon either the exceptional size and mass of its molecular combinations, if solid, or internal friction, if liquid. They are electrochemically uniform. 4. The electrical behavior of any substance is a function of the absolute temperature.

GENERAL AND MISCELLANEOUS.

Magnetic Separation of Ores.—A few of the latest types of the well-known Wetherill separators, as built by the Metallurgische Gesellschaft, of Frankfort, Germany, are briefly described and diagrammatically illustrated by FABRE, in *L'Eclairage Electrique*, September 5. The first type shows an electromagnet system with poles tapering to an edge and having two south poles opposed to a north pole. This type is intended for the treatment of feebly-magnetic materials. The ore is carried on a belt, which moves towards the poles; directly in front of the pole the belt passes down over a small pulley and the ore therefor falls from the belt while under the influence of the magnetic field. The magnetic constituents are attracted towards the magnets above the belt and are carried past them on the lower side of a second belt which travels directly under the magnet. According to the permeability of the magnetic particles they are carried more or less far, and fall into different reservoirs. For the separation of spathic iron ore from blende, it is stated that 1 kw-hour suffices for the treatment of 1000 kilograms of material. In the second type the magnetic materials are attracted towards a belt moving over the magnets at right angles to the feeder belt. The third type presents a cylindrical separator, the magnetic system of which consists of a cylinder composed of a series of rings, which turn between the poles of a magnet. The material to be separated falls upon this revolving cylinder, which becomes magnetic by induction, and carries the magnetic materials around with it according to their permeability.

Aluminium as an Electrical Conductor.—A paper on the above subject was read by KERSHAW before the recent annual meeting of the British Association for the Advancement of Science, and is reprinted in the *London Electrical Review*, Sept. 18. In the first part the author gives statistics on the production of aluminium, a calculation of the relative cost of copper and aluminium, and a short review of recent installations where aluminium has been used as conductor. He then describes a test which he made, and which extended over a period from October, 1899, to December, 1902. Rods and wires, cut into two feet length, were mounted in horizontal frames and exposed to the action of the atmosphere. Tables of the results obtained are given in the article. The summary of the results shows that all the samples of aluminium gained in weight during exposure, and that all were pitted and corroded, especially on the under side, where the water drops had collected and dried. The rods seemed to have suffered less than the wires, and the author therefore thinks it probable that in the course of drawing it down to wire, the aluminium undergoes a physical change. One sample of aluminium, purer than the others, was, nevertheless, badly corroded at the end of one year's exposure. The author states in conclusion that he does not wish to base any unfair conclusions upon these results. He claims, however, to have proved that some of the aluminium rod and wire which was being manufactured and sold in England for electrical purposes in the year 1899 and 1901 was not able to stand atmospheric exposure on the coast of Lancashire without corrosion. It is only a fair deduction from these exposure tests to assert in the opinion of the author, that aluminium manufacturers have yet to prove the metal to be a satisfactory and durable substitute for copper in bare overhead transmission lines, or for electrical work which involves exposure to climates near the coast. It is no more than fair to say that there are numerous chemical works in that district. Mr. Kershaw's observations of the deterioration of aluminium might also be explained by the fact that there is much carbon dust in the air, from the smoke, and that carbon in contact with aluminium, especially when wet with salt water, or rain water containing the chlorine or hydrochloric acid vapors from chemical water, will form a strong battery in which the aluminium is consumed.

Some Alloys of Copper and Aluminium.—The measurement of the thermic effect, which accompanies the formation of copper and aluminium alloys, presents great difficulties, as far as a suitable reagent was concerned, which would act upon both metals of the alloys. LOUGUININE and SCHUKAREFF succeeded by using a solution of bromine in potassium bromide. The results of their work are given in detail in the new *Journal de Chimie Physique*, Vol. I. No. 1, July. They have investigated the alloys Cu_3Al, Cu_2Al, Cu_3Al_2, $CuAl$, Cu_2Al_3 and $CuAl_2$. Higher percentages than 50 per cent of aluminium in the alloys could not be investigated, as the reagent no longer acted with such high amounts of aluminium. The apparatus used by the author is illustrated in the article, and the various steps in the investigation are set forth at length. They find for the heat of formation of Cu_3Al 123.5 cal.; Cu_2Al 137.9 cal.; Cu_3Al 71.0 cal.; $CuAl$ 20.8 cal.; Cu_2Al_3 48.9 cal., and $CuAl_2$ 57.2 cal. Presumably these numbers refer to kilogram calories and gram molecules.

Experiments with Acetylene Lighting in Mines.—A long report made by the German government commission. The question of acetylene lighting in mines., especially coal mines, is investigated in detail, and the various types of acetylene lamps in use in German mines are described. The conclusions indicate that the acetylene lamps have not yet reached the stage of mechanical development, where they can be handled with safety by the miner, though they render valuable service in the hands of mine foremen and officials, for control purposes. *Zeit. f. Carbidfabrikation*, September 11, 18, 25.

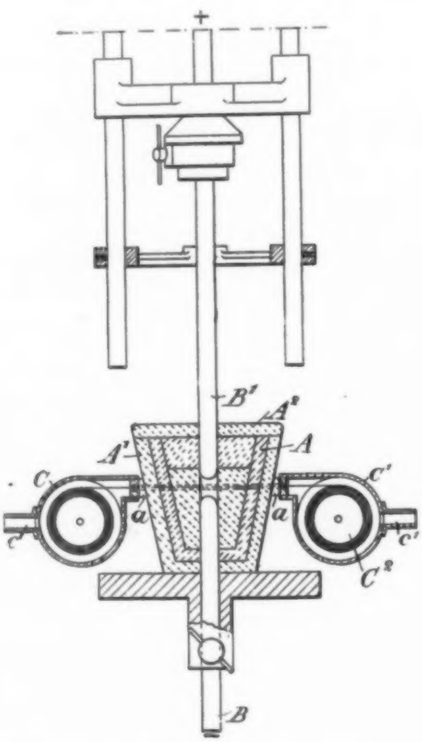
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By George P. Scholl, Ph. D.

Electric Furnaces and Furnace Products.

Electric Furnace for the Manufacture of Filaments.—W. L. Voelker, Erie, Pa. Patent 740,379, September 29, 1903. Original application filed March 15, 1902. Divided and refiled April 10, 1903.

The furnace described in the specification is intended to be used for the manufacture of filaments for incandescent electric lamps. It consists essentially of a black-lead vessel A, crucible-shaped and enclosed in an outer vessel A_1 of refractory materials. Two opposing sides of the inner vessel are provided with perforated extensions a, a, which pass through openings in the outer vessel. A drum C, C_1 is mounted opposite each of the extensions, on which the filament is wound. The latter passes from one drum into the corresponding passage a, then through the interior of the graphite crucible



FURNACE FOR MAKING FILAMENTS.

and out at the opposite side through the other passage a, onto the second drum. The arc is struck between a pair of vertical electrodes B, B_1, and the carbon filament does not pass directly in the center line of the electrodes, but somewhat to the front of them, the wall of the crucible being hollowed out for that purpose. The arc is deflected into this hollow and onto the filament by means of a magnet. In making a graphite filament the interior of the furnace is lined with a consolidated purified sugar carbon, which extends about half-way up the crucible. Above that the inventor places a highly refractory oxide, such as thorium oxide. The cover A_2 is then put on, the arc struck between the electrodes and the interior of the furnace brought to a white heat, after which the filament is drawn through. If it is desired to form a filament composed of the carbides of certain metals, the filament may or may not be treated with a solution of the metallic salts previous to drawing it through the furnace. In this case it is necessary to line the entire crucible with the oxide of the selected metal or metals, and before passing the filament through the furnace, the lining immediately surrounding the arc must be converted into a carbide and then into a metal. What particular carbides he proposes to use, is not disclosed by the inventor. The furnace is so arranged that gases may be passed into the interior of the furnace, by connecting the passages c, c_1, with the gas supply.

Electrolytic Production of Metals and Compounds.

Electrolytic Diaphragm. E. A. Byrnes, Washington, D. C. Patent 735,464, August 4, 1903. Application filed May 12, 1903.

The diaphragm described in the specification is primarily intended for the electrolysis of alkali metal compounds, but is capable of general application. The diaphragm consists essentially of fragments of a suitable size of an electrically conductive material. The thickness of the layer depends on the requirements of the special case in which it is employed. It may be supported by placing it between sheets of a foraminous material or by incorporating with it a suitable amount of an inert binder in order to make it self-supporting. If the cell has a cathode of molten lead the diaphragm may rest directly upon the molten material. In the case of the electrolysis of brine, a cell is described which has a diaphragm of magnetite or ferroferric oxide. It is stated that this will resist the action of alkaline chlorides and nitrates and their electrolytic products Ilmenite or chromite are stated to be also available, and broken glass or porcelain to be suitable for use in aqueous electrolytes. The fragments may be of a size to pass a fifty mesh sieve, and the layer itself may be from one to several inches thick. Several forms of application of the diaphragm are described.

Electrolytic Process of Recovering Metals from Their Compounds. C. E. Baker and A. W. Burwell, Cleveland, Ohio. Patent 739,139, September 15, 1903 Application filed November 11, 1902.

This process consists in the electrolysis of sodium chloride, the absorption of the sodium in a mercury cathode and the subsequent distillation of mercury in order to effect the recovery of the sodium. The process is carried out in the apparatus, which has been described at length in Electrochemical Industry, Vol. I., p. 469, with illustration. The latter is reproduced in the specification under consideration.

Apparatus for Oxidizing Metals Dissolved in Mercury. C. E. Baker and A. W. Burwell, Cleveland, Ohio. Patent 739,140, September 15, 1903. Application filed November 11, 1902.

This invention deals with a process of discharging sodium from its amalgam with mercury, after it has been introduced into the latter during the electrolysis of sodium chloride. The apparatus described consists of a rectangular vessel for receiving the amalgam, which latter is covered with a layer of water, the water and the amalgam being kept in continuous movement in opposite directions. A number of roughened pieces of carbon are placed in contact with the amalgam and the water, each body of carbon serving to cause a vigorous reaction between the sodium in the amalgam and the water. The inventors have found that carbon bodies which are produced by forcing a plastic mixture of hydrocarbons and carbon through a die and baking the resultant product, are entirely unsuitable for use in this connection. This is attributed to a thin outer layer of substantially pure carbon, which is formed on the outer sur-

face of the objects which does not come into satisfactory metallic contact with the mercury. If this original surface, however, is removed by mechanical means and the inner portion exposed, the latter is readily wetted by the mercury.

Method of Electrodepositing Metals. C. R. Fletcher, Boston. Patent 740,359, September 29, 1903. Application filed May 28, 1900.

The specification describes a method for the more rapid and uniform coating of metallic sheets, brought about by rotating the cathode. The apparatus proposed by the inventor consists essentially of a rectangular vat, in which a sort of a cage of metal is suspended from a roller, which can be rotated. This cage, called by the inventor the cathode base, is formed of several rings of metal, preferably of copper or brass, held together by metallic rods. The cages serve for the support of the sheets to be electroplated, which are fastened to them by means described in detail in the specification. The sheets receive deposit from both sides, there being an anode arranged inside of the cage and another one outside of it. The inventor states that for this purpose he employs by preference two independent sources of electricity, for the reason that with them the volume and the pressure of the currents can be better sustained than by using resistance coils, which exert a varying influence on the current as they become heated, and therefore require constant attention, when work is carried out on a practical scale. The advantage of the rotary cathode is, of course, the possibility of carrying a greater current density for plating purposes than is possible with a stationary one.

Art of Making Bleaching Compound. Marcus Ruthenburg, Harrisburg, Pa. Patent 739,448, September 22, 1903. Application filed January 14, 1902.

The process consists in the electrolysis of a 20 per cent solution of sodium chloride, mixed with an aqueous solution containing 10 per cent of hydrated oxide of lime. The current density is half an ampere per square inch of the electrode surface exposed to the solution, and the pressure is three volts. The material of which the electrodes are composed is not disclosed. The oxide of calcium is employed by preference on account of its low cost, but the oxides of magnesium, lithium, aluminium, sodium and potassium may also be used. It is claimed as advantages of the process that the hydrated oxide of lime prevents the escape of chlorine from the solution during electrolysis, and that it has the effect of increasing the conductivity of the electrolyte.

STORAGE BATTERIES.

Method of Treating Lead Plates for Use in Secondary Batteries. C. J. Reed, Philadelphia. Patent 735,820, August 11, 1903. Application filed February 1, 1902.

The method outlined in the specification consists in subjecting a plate of metallic lead in a closed chamber to the action of hydrochloric acid gas, preferably mixed with an oxidizing agent, as nitric acid, nitric oxide, nitric peroxide, chlorine or bromine. The hydrochloric acid gas may be mixed with those oxidizing agents before entering the treating chamber, or they may be introduced separately. The former method is preferred. The formation of lead chloride is stated to be much promoted if the surface of the plate under treatment is kept in a moist condition. The plates are moistened as soon as they become dry, through the action of the gases by submerging them in water or in a solution containing hydrochloric or nitric acid. The time between the applications of the moistening liquid may vary from 2 to 5 hours. A vessel is provided in conjunction with the treating chamber, which vessel contains the solution, and from which a sufficient amount of the latter is forced by air pressure into the treating chamber. After the pressure is released, the solution flows back into the reservoir by syphon action. It is preferred to convert the chloride of lead thus formed into spongy lead by contact with zinc in a solution of zinc chloride, and to subsequently oxidize them by the ordinary process of charging.

Secondary Battery Plate and Method of Making Same. A. F. Clark, Philadelphia. Patent 736,217, August 11, 1903. Application filed December 28, 1901.

The specification illustrates and describes a process for making battery plates of a grid shape. The plates are formed in two operations, the first mould being of such shape, that the spaces between the gridbars can be filled with active material after the first compression. In the second operation the gridbars, with the active material between them, are flattened out in such a manner that the active material is securely held. An apparatus for rolling down the plates into the desired shape is shown in the specification.

Storage Battery. A. V. Meserole, New York. Patent 736,125, August 11, 1903. Application filed May 14, 1903.

The cell described in this specification consists of a containing vessel of any desired insulating material, which contains two electrodes of peculiar construction. One electrode consists of a metallic ring, placed on the bottom of the vessel, integral with which are cast a number of tubes of the same material as the ring, and projecting upward. One of these tubes is much longer than the others, and serves for the purpose of making the electrical connection. Each two of the tubes carry a set of peculiarly shaped bodies, called "wafers" by the inventor. They are formed by spreading the active material in the form of a plastic paste into thin layers, each of which is preferably of the consistency of stiff dough. A number of these layers are placed on top of each other, a sheet of metal is placed at the top and bottom of the pile, and other layers are added, so that the whole forms a composite structure consisting of a metal sheet at the top, several layers of active material, another sheet of metal, some more layers of active material, etc. The desired shape is then cut out from the superimposed sheets by means of a stamp. For the outer electrode they are preferably in the shape of a kidney, while the ones forming the central electrode are annular. The latter are mounted upon a single tube, much larger in diameter than those of the outer electrode, and serving as the second electrical connection. It is claimed that by constructing these "wafers," the active material is disposed to better advantage, and that expansion and contraction are provided for.

Separator for Secondary Batteries. A. F. Clark, Philadelphia. Patent 736,216, August 11, 1903. Application filed July 22, 1901.

The separator is adapted for use with the inventor's type of battery, as described in the preceding specification. It is formed of some non-conducting material capable of being molded, as hard rubber, porcelain, earthenware, celluloid, etc. The separator is made up of a series of cross-bars, shaped so as to enter a space between the grates of the grid, mentioned in the description of the above cell, which constitutes the framework of the electrodes, and the active material. The cross-bars of the separator are held together by means of ribs of triangular cross-section. Several modifications of the construction are described.

Secondary Battery. G. E. Hatch, Quincy, Mass. Patent 738,188, September 8, 1903. Application filed February 13, 1899.

The negative electrodes of this battery are constructed by filling red lead into thin porous plates, formed in the shape of a shallow tray on both sides. These plates are made of thin, porous wood, and are provided with a number of holes. The positive electrodes are composed of a rigid porous support plate, preferably made of kaolin or a similar acid-resisting material containing no iron, which are provided with a number of parallel grooves. The grooves on one side of the plate are filled with active material in the form of a paste as usual. Conducting plates are employed, made from thin sheets of metallic lead and provided with a number of perforations, designed to serve as reservoirs for the electrolyte. The cells are built up by placing a positive plate with its pasted side against a conducting plate, the grooves being vertical for the

purpose of circulation of the electrolyte. A pasted negative plate is placed against the other side of the positive plate, facing the non-conducting support plate of the latter, and a conducting plate is placed in turn on the other side of the negative plate. The couples are held together by glass or other acid-resisting plates on the outside, held in position by rubber bands.

Process of Producing Active Material and Electrodes for Storage Batteries and Products Thereof. O. P. Fritchle, Denver. Patent 738,313, September 8, 1903. Application filed January 7, 1903.

This invention is stated to be based on the discovery that granulated lead, if sprayed into a hot solution of hydrochloric acid, obtains a peculiar cohesive property, and can be easily compressed by comparatively slight pressure into a rigid but highly porous mass. An apparatus for carrying out this invention is described in the specification. The hydrochloric acid used is preferably a 5 per cent solution; a solution of any other acid, salt or compound which will yield chlorine to the lead, or chlorine water, or chlorine itself, may be employed. It is said to be important that the treated lead should be compressed without delay, as its property of welding is soon destroyed by the action of the acid. The granulated lead should have a fineness of between 60 and 100 mesh. To granulated lead after passing through the acid may be received directly on the bottom of any suitable vessel and compressed into a highly porous and self-supporting electrode of sufficient rigidity for practical use.

Apparatus for Producing Active Material and Electrodes for Storage Batteries. O. P. Fritchle, Denver. Patent 738,314, September 8, 1903.. Application filed January 7, 1903.

This specification patents the apparatus, identical with that shown in the preceeding one, for carrying out the process described above.

Process of Producing Active Material and Electrodes for Storage Batteries and Product Thereof. O. P. Fritchle, Denver. Patent 738,427, September 8, 1903. Application filed March 18, 1903.

In this specification it is claimed that finely divided lead obtains a peculiar cohesive property also when sprayed into a hot dilute solution of acetic or nitric acid, or of sodium or potassium hydroxide. The apparatus for carrying out the process is the same as that described in the preceding specification.

Storage Battery. F. A. Redmon, Chicago. Patent 738,942, September 15, 1903. Application filed March 16, 1903.

The plates of this battery are constructed in the following manner. A perforated metallic blank is provided, consisting of two portions united by an unperforated part. One portion of the blank has wider margins than the other. The active material is spread upon an absorbent substance like burlap, matting or a similar fibrous material. This treated material is then placed upon that portion of the blank which has the narrower margin, and the other portion bent about and placed over it, the wider margins of the latter serving to be folded over the edges of the smaller portion of the plate so as to form a pocket. The structure is then placed between dies and compressed and corrugated at the same time. Any desired number of these plates may be assembled to form a battery, by spacing them apart by a separator, composed of a perforated sheet of insulating material corrugated transversely with respect to the corrugations in the plate.

Terminal for Storage Batteries. J. W. Madigin, Toronto, Canada. Patent 739,432, September 22, 1903. Application filed January 10, 1903.

The terminal construction described in the specification is arranged with a view to provide a non-corrodible connection. An iron bolt is cast into the terminal, into which is screwed a leaden nut, which contains an iron nut within it. When the nut is screwed home, it holds in place a ring of lead, into which the end of the connecting wire is cast. No iron surfaces are, therefore, exposed.

Storage Battery. J. T. Niblett, Greenwich, London, England. Patent 740,034, September 29, 1903. Application filed August 8, 1902.

The invention is intended to improve both the active material of the plates and the porous separators. It consists in adding to the active material of the plates, and to the substances from which the separators are made, a certain amount of infusorial earth, "kieselguhr." It is claimed that the mixing of kieselguhr with the active material brings about a great degree of permeability of the resulting plates, the fibers of the kieselguhr acting as minute ducts to convey the electrolyte into the body of the material by capillary attraction. The proportion of kieselguhr may be 1 to 5 per cent for the positive, and 2½ per cent for the negative plates. It is claimed that very satisfactory plates may be made up of about equal parts of litharge and red lead, mixed with 2½ per cent of kieselguhr and then molded into the desired shape. The separators are formed wholly or principally of kieselguhr wetted with f. e. sodium silicate, and molded into thin slabs, which are burned to render them hard and firm.

On account of limitations of space a large number of patents had to be reserved for our next issue.

NEW YORK SECTION OF THE AMERICAN ELECTRO-CHEMICAL SOCIETY.

At the recent meeting of the American Electrochemical Society in Niagara Falls, the formation of local sections was approved by the Board of Directors, the first local branch to be established at Madison, Wis. Members from New York attending the meeting informally expressed themselves in favor of the formation of a New York Section. In consequence of this Mr. Alois von Isakovics sent out a circular letter to all members in New York City, and vicinity within 20 miles, to attend a preliminary meeting at the Chemists' Club on October 10, for considering the advisability of organizing a New York Section. Owing to very bad weather the attendance was small (but not smaller than at the first preliminary meeting held in Philadelphia in 1901, at which the advisability of the formation of the American Electrochemical Society was considered). A larger number of New York members, however, had expressed their approval of the scheme by letter or telephone messages. After some discussion, in which Dr. C. A. Doremus, Dr. H. Poole, Dr. G. W. Maynard, Mr. J. Bijur, Mr. A. von Isakovics and others participated, the formation of the section was unanimously approved, and Dr. C. A. Doremus was elected chairman and Mr. A. von Isakovics secretary. The date of the first meeting has not yet been decided, but it is probable that at this occasion Dr. Doremus will speak on the very elaborate equipment of the chemical laboratories of the new College of the City of New York. It was also proposed that several short papers of, say, five or ten minutes, should be read at one session. In such short and more informal talks the speakers could discuss questions which come up in their practice, and which they do not think important enough for preparing an elaborate paper before the general society. It is hoped that such informal talks will bring out very good discussions, and that the sessions of the New York Section of the American Electrochemical Society may become a rendezvous; not only for electrochemists, but for chemists, electrical engineers and mining and metallurgical engineers in general, and will do a great deal toward bringing these various classes of engineers together.

The business of the Section will be conducted by an executive committee of five members, consisting of the chairman and the secretary, and three members to be appointed by the chairman. Invitations to the first meeting will be duly sent by the secretary to all members in New York City and vicinity.

Correspondence.

CYANIDE SILVER PLATING BATHS.

To the Editor of Electrochemical Industry.

Sir—I would like to reply to Mr. Hering's remarks on my communication (page 514 of your October number) in which he takes issue with me in regard to certain statements by Messrs. Jordis and Stramer, as to the loss of "cyanide" and increase of carbonate in the plating baths referred to, and in which he claims that the "contradiction" I pointed out does not exist, because the authors quoted do not specify the "ratio of such loss and increase." Now, in my remarks I said nothing whatever about "ratio." My contention was, and is, that the loss of cyanogen does not result in an increase of "carbonate," as the authors state, for the simple reason that the equivalent of CN which passes off and constitutes the loss complained of by electroplaters, leaves the equivalent of potassic carbonate with which it was combined in the bath, no more and no less. Hence, the increase of "carbonate" which they refer to could not possibly take place. If the authors named had merely stated that the loss of cyanogen was greater with a working solution than with an idle one, the statement would have been in accordance with the experience of every silver plater. But there could be no increase of potassic carbonate as they intimate. In the latter part of their article quoted by Mr. Hering, they say: "It has been found that after a while more cyanide disappears than is equivalent to the amount of carbonate found." Here is where the contradiction comes in. If a thing or part of a thing can't be found then it must have been lost, or disappeared. Taking the two declarations of Messrs. Jordis and Stramer on the "carbonate" question, if they do not constitute a contradiction, I fail to see what arrangement of words would. The fact is that their statements on the "carbonate" matter are both wrong. There is neither increase nor decrease.

The closing declaration of Mr. Hering that "the loss of cyanogen necessarily involves a loss of cyanide" is not in accordance with the facts, because argento-potassic-cyanide is a definite fixed salt, but all cyanide plating solutions require a certain amount of free cyanogen to ensure a good working condition during electrolysis, enough to effectually and continuously dissolve the oxide formed on the anodes during the process of electrolysis. It is this constant and rapid loss of "free" cyanogen that gives the electro-silver plater so much trouble, but the fixed salt is comparatively unaltered. Hence, whatever the loss of "free" cyanogen which may occur in a plating bath, the "cyanide" is there all the same, though the solution may not work satisfactorily when in this state. But just add a little HCN gas or liquid, and the solution will, under electrolysis, immediately dissolve the oxide from the anode and deposit its metal on the cathode as freely as before. Loss of cyanogen does not necessarily involve loss of "cyanide."

Cincinnati, Ohio. James Powell.

A SUBOXIDE OF SILICON.

To the Editor of Electrochemical Industry.

Sir—I wish to say a few words in connection with the note of Mr. F. A. J. FitzGerald on "an alleged suboxide of silicon," published in your October issue, page 514. At the time the work was done on this substance, I knew of the work of Colson and Schuetzenberger, and I recollect that we tested for the presence of carbon in the substance analyzed with a negative result.

Mr. H. L. Payne, who assisted me in a part of the work, has the same recollection. Unfortunately, all notes relating to that work were destroyed by fire soon after the experiments were made, as well as the material. The description of those results is given in the *American Chemical Journal*, 1887, page 14.

C. F. Mabery.

Cleveland, Ohio.

DATA CONCERNING PLATINUM.

Messrs. Baker & Co., the well-known gold, silver and platinum refiners, of Newark, N. J., have just issued the eleventh edition of their booklet, "Data Concerning Platinum."

The following notes on the use and care of platinum ware should be of general interest. Although platinum is not oxidized in the air at any temperature nor attacked by any single acid, yet there are many substances that attack and combine with it at comparatively low temperatures. The caustic alkalies, the alkaline earths, nitrates and cyanides, and especially the hydrates of barium and lithium, attack platinum at a red heat, although the alkaline carbonates have no effect at the highest temperatures. Sulphur, in the absence of alkalies, has no action, but phosphorus and arsenic attack platinum when heated with it.

Direct contact of platinum with burning charcoal should be avoided, since the silicon reduced from the charcoal ash unites with platinum, making it brittle and liable to fracture. Also contact with compounds of the easily reducible metals is especially dangerous at high temperatures, as alloys with platinum having a low fusing point are readily formed. This is especially true of lead.

Heating of platinum with spirit lamps is preferable to the use of ordinary gas. When gas is used, care should be taken to have the supply of air sufficient to insure complete combustion, since, with the flame containing free carbon, the platinum suffers deterioration by the formation of a carbide of platinum, which, oxidizing later, blisters the metal. For this reason, also, the inner cone or reducing flame should not be in contact with the metal. The loosening effect of the Bunsen flame upon the surface of platinum exposed to its action produces the familiar gray appearance, which cannot be removed except by burnishing. Platinum triangles often become gray and very brittle from the same cause. Systematic application of moist sand to all articles affected in this way, after use, will keep them in prime condition and materially prolong their life with but a trifling loss in weight.

Every careful analyst of necessity uses clean utensils. A habit of cleaning and polishing platinum dishes immediately after using is easily formed, and repays the user with increased confidence in his work as well as in the prolonged life of the article. Rubbing the surface of platinum with moist sea sand (round grains only), applied with the fingers, serve to remove most impurities and to polish the metal without material loss.

Fusing bisulphate of potash or borax in the dish and then boiling in water and polishing as above with sand is recommended by Gmelin. When it is desired to clean the outer surface of dishes in this manner, they must be placed in dishes of sufficient size to allow the fused flux to completely envelope the article to be cleaned.

Sodium amalgam possesses the property of wetting platinum without amalgamating with it, even when other metals are purposely added to the amalgam. This substance is, therefore, useful for effecting a quick and thorough cleansing of platinum. The amalgam is gently rubbed upon the metal with a cloth and then moistened with water, which oxidizes the sodium and leaves the mercury free to alloy with foreign metals. The mercury is then wiped off and the dish cleaned and polished with sand, as above described.

If the existence of a base metal alloyed with the platinum is suspected, the article in question is first immersed in boiling HCl for a few minutes, then, after thorough rinsing with clean water, immersed in boiling HNO_3, free from chlorine. If the dish is unaffected in weight or appearance, and the acid baths fail to give reaction for the base metals, their absence in appreciable quantities is assured.

Besides illustrated descriptions of platinum stills for the concentration of sulphuric acid and of Howard's density regulator, and illustrations of the standard sizes of platinum

dishes, crucibles, retorts, bottles, pots, dipping baskets for jewelers, anodes and cathodes for electrolytic separation, and of the various platinum apparatus for analytic and general laboratory work, the booklet contains a greater number of very valuable tables as follows: atomic weights; comparison of troy, avoirdupois and French weights; comparison of wire gauges; comparative table of lengths, areas, and volumes; conversion of thermometer readings; weight and electrical resistance of copper wire; decimal parts of a millimeter expressed in decimal parts of an inch; diameters of platinum wire fused by electric current of given strength; fractional parts of an inch expressed in thousandths; number of feet of platinum wire per troy ounce; number of square inches of platinum sheet and foil per troy ounce; specific gravity, specific heat, latent heat of fusion, and approximate melting point of metals; density and boiling points of sulphuric acid; weight per foot of platinum wire in troy and French weights; weight per foot of platinum wire in troy ounces; weight per square inch of platinum sheet or foil in ounces, dwts., grains and grammes; weight per square inch of platinum sheet or foil in troy ounces.

The following information concerning fuse wire is of interest. The fact that platinum does not oxide at any temperature greatly increases the surety of the interruption of the electric current only at a predetermined point, and for this reason platinum wires are coming gradually into more extended use for protective fuses in electric circuits of small current capacity, especially telephonic and telegraphic circuits, for which purpose the small section of the fuse wire required renders the cost insignificant. According to a formula of W. H. Preece, the diameter of a platinum wire has the following relation to the current which will fuse it:

$$D = (0.00019335\ C)^{2/3}$$

where D is the diameter of the platinum wire in inches and C the current in amperes required to fuse. The booklet contains a table, based on this formula, giving the diameter in inches for different values of the current for a fixed length of 6 ins. of wire between supporting terminals.

The electric resistance of commercial platinum is approximately ten times that of copper; specific heat = 0.03243 (Regnault), the coefficient of linear expansion at 40° is 0.00000899 (Fizeau), and the coefficient of cubic expansion per degree C. is 0.000026 to 0.000029 (Watts). The booklet is very neat in appearance and should be quite useful to anybody who has to use platinum apparatus.

PROSPECTING GOLD DREDGE WITH STEEL HULL.

Next to electrolytic copper refining, the treating of gold ores is that field of metallurgy in which electrochemical methods have found the largest commercial application; we refer, of course, to those cyanide processes in which the electric current is used either for dissolving the gold in the cyanide solution or for precipitating it from the same. On the other hand, the chemical method of precipitating gold from a cyanide solution by means of zinc shavings is at least of equal commercial importance, while the purely mechanical processes of treating ore or sand will always remain matters of the greatest moment for the gold metallurgist. In fact, the modern gold metallurgist must be an all-round man, well trained in many fields; he must be a mining, mechanical and electrical engineer, a chemist and an electrochemist. With the steadily increasing use of electric power in metallurgical plants, it may be expected that electrochemical methods will find more and more favor with metallurgists because a highly effective agent for producing chemical action, in form of the electric current, is now readily available. On the other hand, the electrochemist who approaches the field of metallurgy must endeavor to become acquainted with those non-electrochemical methods and apparatus which he either has to use for a preliminary treatment or with which he has to compete. For this reason we believe our readers to be interested in the modern design of gold dredges to which we have already referred repeatedly in our columns.

The adjoining diagrams show a new gold dredge which is being brought out by A. W. Robinson, 14 Phillips Square, Montreal, Canada, especially for exploration purposes. It is designed to be a light and powerful dredge with sufficient strength and capacity to enable it to clean up bed rock at 22 feet depth and to handle free material at the rate of 60 tons per hour. Although very small and light, it is provided with all the motions of larger and more powerful machines, and its working parts are as few and simple as possible. It is built wholly of the best grade of steel and with no cast-iron entering into its construction whatever except such parts as cannot be made of any other material so well, such as the engine cylinders. The principle of the machine is simplicity itself. There are but two working shafts in the whole of the upper machinery driving the buckets and screen. These are mounted on a steel frame which is very strong and light and readily put together.

The dredge is erected and fitted up complete at works before shipment, and all principal parts of machinery tested in operation. The time, expense and labor of erecting and fitting up the dredge at its destination is thus reduced to a minimum, and the work required will only be that of putting the parts in their place, where they have been before. The arrangement of the parts is such that the various movements are accomplished with directness and simplicity, and so that all the operations are under the control of one man. For facility in shipment, all parts are made as light as possible, and subdivided into convenient sizes and weights.

The dredge is fitted with steel buckets having a nominal capacity of 1.5 cubic feet each. The material as excavated by the buckets is delivered into the hopper and passed through a revolving screen and washed therein. The coarse tailings from this screen are rejected and discharged by means of a gravity chute. The fine material contained therein passes through the screen into a long sluice box fitted with riffles, by means of which the gold is saved. The perforations in the screen are of such a size that about 20 per cent of the material is rejected and discharged over the side, and about 80 per cent passes through the sluice box, and is discharged astern.

The movements of the dredge are controlled by wire ropes attached to anchorages or on shore. For this purpose an independent steam winch is furnished having six drums.

The hull is of steel 72 feet long, 22 feet wide and 4 feet 6 inches deep; it is formed of two pontoons catamaran style. Each pontoon is 8 feet wide, and they are connected together by steel girders placed in suitable position. For convenience in shipment the hull is subdivided according to the conditions of the case. Where the locality can be reached by rail or wagon haulage, the hull is shipped in six sections, riveted up complete. Wherever necessary the hull is shipped in a knocked-down state, every piece being first fitted to position, so that the work of putting it together is reduced to a minimum.

The bucket chain is formed entirely of steel forgings and steel plates. The lip-plates of the bucket forming the cutting edge are of a special grade of hard and tough steel 8 inches wide and ⅝ inches thick. The pins are of manganese steel, and the pin joints are fitted with hardened steel bushings arranged to be renewable.

All the fittings and attachments of the dredging apparatus are of strong and light construction. The tumblers are of cast-steel, and the ladder frame itself is of steel.

A steel-plate hopper receives the discharge of the buckets and conducts it into the mouth of the screen. This hopper is made in sections attached to the main framing, and all parts subject to the wear of the material have renewable lining plates.

A cylindrical revolving screen, built of perforated steel

plates, is placed so as to receive the material from the hopper. It is set at an inclination of 1 to 12, and is of sufficient diameter to receive all the material that the buckets can deliver without choking. The screen is built with a steel frame having perforated plates attached to it in such a way that they can be readily renewed or replaced without taking the screen apart.

The upper tumbler is driven by a steel gear from a steel pinion on the countershaft. The main gear is 6 feet in diameter. The countershaft has a steel pinion on one end of it which engages with the main gear and a belt pulley 6 feet diameter by 14 inches face on the other end, and it is connected to the main engine by means of a belt. The belt thus furnishes a frictional medium for the transmission of power, so that the parts are relieved from sudden strain. The main and countershafts are carried in cast-steel bearings lined with babbit metal and securely bolted to the steel framing.

The screen is carried within a screen box formed of steel-plate and having suitable supports within it for the rollers upon which the screen will rest. The screen box also has the necessary pipe connections for the sluicing water, which is furnished by the centrifugal pump.

A steel plate stone chute is provided for carrying off the coarse tailings.

The main engines are of the vertical marine high-pressure type, of 32 indicated horse-power. They are built of special design to combine strength with lightness. All important bearing surfaces are extra large, adapted for continuous hard work, and complete provision is made for continuous lubrication. The engines have plain slide valves and turned steel column frames. The engines are fitted with a throttle valve and link motion, which is controlled from the operator's platform by levers and rods.

Water for sluicing purposes is supplied by an independent centrifugal pump having 8-inch suction and 6-inch discharge, placed upon the main deck, as indicated on drawings. The engines for driving this pump are of the vertical high-pressure type. The pump discharges part of its water into the head of the sluice box and part into the head of the screen, regulated as desired.

For the purpose of working the mooring lines and raising and lowering the bucket ladder an independent winch is furnished having six drums. Each drum will be fitted with independent clutch and brake for perfect control of the various motions. The winch is also fitted with a capstan head for general hauling and warping purposes. This winch is to be entirely of steel, no cast-iron being employed in its construction. The drums are of steel-plate with cast-steel heads and pressed-steel plate flanges. All the gears are of steel, and the frame is built up of steel plates and channels.

The two forward drums are provided with a powerful band-brake to each, the bands being made of steel lined with wood blocks. The standing part of the band is secured to the steel deck, and power is delivered to the bands by cross-shafts and levers connected with the operator's platform.

The four small drums are fitted with four standing brakes and provided with suitable adjustment.

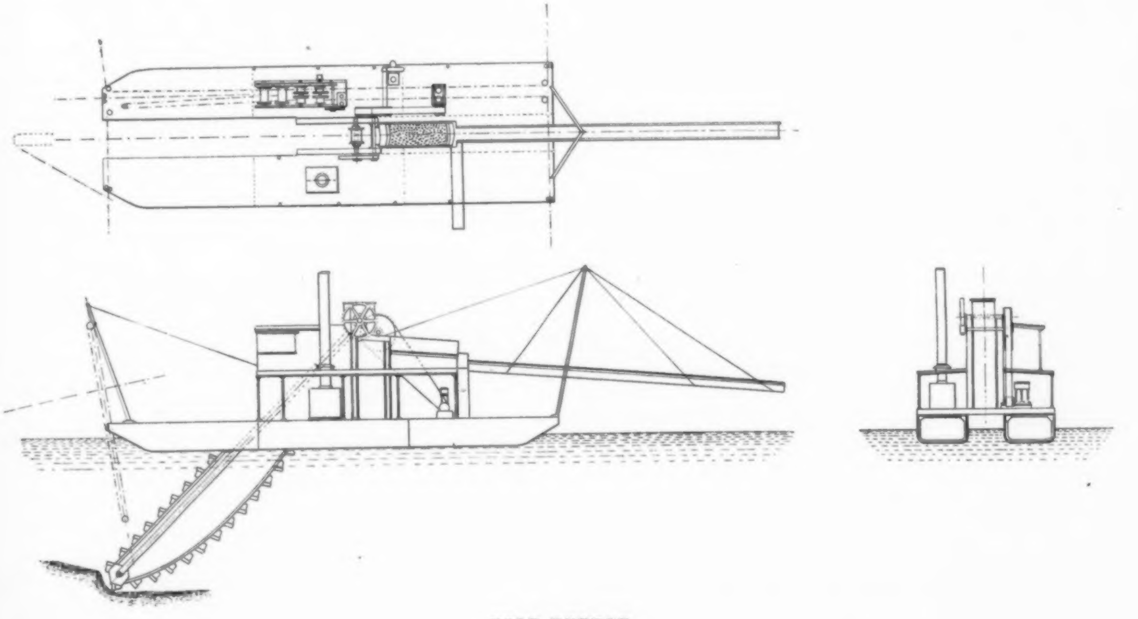
The winch is driven by a pair of double reversible high-pressure engines having steel columns and frames similar in all respects to the main engines.

The movements of the dredge are controlled from the operator's platform on the upper deck on the starboard side directly over the winch. All lever connections for operating the winch are placed here in convenient position, and also levers for the main engines. In this manner the entire dredge can be operated by two men, not including those employed in fuel supply.

Steam will be furnished by one boiler of the water-tube type. This boiler will be specially built for the work and adapted to burn inferior wood and occupying small space and weight.

The bucket ladder is suspended from a steel frame by means of a wire rope tackle of ample strength. The hauling part of this tackle is carried to the winch, as before described. The suspension tackle is of sufficient capacity and lift to raise the bucket ladder from its maximum depth to 2 feet clear of the water.

The sluice box extends over the stern of the dredge, as indicated on the drawing. It is built entirely of steel and suspended by steel wire ropes mounted on a strong A-frame. The sluice box is fitted for its entire length with steel riffles of a size and character adapted to the gold to be saved. The bottom of the screen box is also fitted with riffles.



GOLD DREDGE.

As will be seen, the dredge is manipulated entirely by wire-rope anchorages, no spuds being employed. A complete outfit for all purposes is furnished with the dredge of best quality of cast-steel rope, galvanized to protect them from rust. This method of mooring enables the dredge to be used conveniently in almost any situation. It can work as well in an open river, with a current of six to eight miles per hour, as in an enclosed pond. It can dig its own flotation through dry ground above water level, and the sluice box is high enough to dispose of the tailings without the necessity of using a tailings elevator.

It is now recognized that the only really satisfactory way to test a gold-dredging property is by means of a dredge, and it is thought to be far better economy to begin with a small and light machine such as is here illustrated, which will furnish exact information as to the conditions to be met with, rather than to try experiments at the outset with a large and costly dredge, which may or may not be a success. This dredge is large enough to more than pay its working expenses if gold exists in the ground, and if the conditions are such as to warrant greater expenditures and larger machines they can then be entered upon with absolute assurance of success.

Mr. Robinson has been a dredge designer for twenty-five years, and has built more than 125 dredges of all types for all purposes, making a specialty of designing dredging machinery to suit the special conditions under which they have to work.

HEATING AND VENTILATING EQUIPMENT FOR THE SHOPS AND OFFICES OF THE PENNSYLVANIA STEEL COMPANY, AT STEELTON, PENNSYLVANIA.

The Pennsylvania Steel Co. has recently erected at Steelton, Pa., a large shop and an office-building for its bridge and construction department. The system of heating and ventilating has been designed with much care, and exemplifies the latest practice in large, one-story structures.

For such buildings the fan and heater, or "hot-blast" system, is now considered to be the most suitable. In this system the steam piping is concentrated in a compact heater, which is enclosed by a steel housing. Due to the greater velocity of the air over the pipes of the heater, much less length of pipe is required than if the piping were scattered throughout the shop, and all dangers from freezing and bursting of pipes, setting fire to woodwork, etc., are of course eliminated. Air taken either from the shop or from out-of-doors is forced through the heater by a fan and is then carried to various points about the shop by a system of galvanized iron piping. The exhaust from the fan engine is condensed in a section of the heater arranged for that purpose, and there is, therefore, no loss of steam due to the engine.

The distribution of the heated air in the shop is a very important question and requires for its proper solution great care and long experience in this class of work. The hot air should be so delivered that there is no perceptible draft upon the workmen, but at the same time the outlets should be placed at short intervals apart and directed towards the floor, since that is where the heat is wanted. By this means it has been found possible, as in the works of the New York Shipbuilding Co., at Camden, N. J., to keep a zone of 9 or 10 feet in height comfortably warm, while the space overhead is in comparatively free communication with the outside air. This would be impossible with direct heating, or if the hot air were delivered through a few large outlets in the upper part of the building, as is sometimes practiced.

In the bridge and construction shops of the Pennsylvania Steel Co. there are 8 fan and heater equipments, consisting each of a steam-coil heater in connection with a steam engine-driven exhaust wheel. The heaters, with the remainder of the equipment, were furnished by the B. F. Sturtevant Co., and are built on that company's patent, corrugated cast-iron sectional bases, with 1-in. steam pipes set staggered and at the proper distance on centers to obtain the highest efficiency from the heating surfaces without restricting the passage of the air. The sections rest on heavy wrought-iron bases, with ample provision for contraction and expansion. The fans are enclosed in three-quarter, steel-plate housings, the lower part of the fan scroll being underground and forming a part of the foundation. They are driven by direct-connected, horizontal, side-crank engines. A system of galvanized iron pipe distributes the air throughout the buildings, the air being discharged through branch drop-connections having outlets near the floor. The ducts are of large size, with bends of long radius to reduce the frictional losses to a minimum. Each drop pipe is fitted with a butterfly damper, with a counter-weight for holding the same open or closed as may be desired. The entire apparatus is of sufficient capacity to heat the buildings to 60° F. in zero weather. In the case of the receiving shed, this applies only to a section 50 ft. in width in the middle of the building, but extending its whole length. Under the conditions of the contract the heater must take all the fresh air from out-of-doors. However, as the number of occupants in the building are few compared with the cubic contents, it will be found perfectly feasible and more economical to return a certain portion of the air from the buildings, and the apparatus is so arranged that this can be done. The apparatus is capable of changing the air in all the buildings every 25 minutes, and in the paint shops every 20 minutes.

The office building in connection with this department is heated by the same method, the apparatus being designed to furnish 21,430 cubic feet of air per minute, which is discharged into rooms having a total capacity of 289,763 cubic feet, thus providing for a complete change of air about every 15 minutes. The fan of the office-building heating-plant is not driven by a steam engine, as in the case of the sets furnished for the shop, but is direct-connected to a Sturtevant motor running at 200 revolutions per minute.

INDUSTRIAL NOTES

Messrs. FRED. BERDUCH & Co., of New York City, sole agents for the *Deutsche Steinzeugwaarenfabrik für Canalisation und Chemische Industrie*, of Friedrichsfeld, Baden, Germany, have sent us the latter company's price list of stoneware vessels and apparatus for chemical, electrochemical and galvanoplastic industries. The catalogue is an exceptionally comprehensive and neat one and includes many colored plates, showing complete installations of salt cake and hydrochloric acid plants for the decomposition of about four tons of salt in twenty-four hours; Glover towers, intermediate towers and Gay-Lussac towers for sulphuric acid plants (Guttmann's ball tower being one of the most recent apparatus in this line); nitric acid condensing apparatus for the decomposition of 16 cwt. of nitre in twelve hours; denitrating plants; regenerating plants for use in smaller chemical works for nitrating operations; acetic acid rectifying apparatus; distillation apparatus for making acetic acid absolutely free from metals for medicinal purposes; Guttmann's reaction towers; Franz's condensing apparatus, condensing towers filled with Hoffman's cascade bands; distilling plants for fine chemical products; witherite and arsenic acid plants; stoneware pumps, exhaust fans, condensing vessels, etc. The company manufacture Dr. Buchner's patent material, which is a refractory and acid proof ceramic product; the porous diaphragms prepared from this material, although somewhat thicker than the ordinary ones, are said to offer excessively small resistance to the passage of the electric current, while they will prevent diffusion effectively. These diaphragms are also stated to be mechanically very durable. While the company manufacture plants for industrial operations on a large scale, they also make apparatus and vessels

for laboratory work and especially apparatus for electrolytic purposes in great variety.

SPARKING POINTS FOR AUTOMOBILES.—We have received from Messrs. Baker & Co., of Newark, N. J., the eleventh edition of their "Data on Platinum" (see page 555 of this issue), also a list of the sizes of platinum rivets furnished by this company for use as contact points in telephones and other electrical apparatus, and a pamphlet with the title "Points for Automobilists." In the latter it is pointed out that the uninterrupted and efficient operation of automobiles propelled by hydro-carbon motors, depends to a large extent on the design and construction of the ignition device. To get an effective spark, it is necessary to get a good contact between the sparking points, and for this reason it is necessary to use points of a non-oxidizing and non-disintegrating material. As the sparking points are inserted within the combustion chamber of the engine, where there is a very high temperature, the points are very liable to disintegrate. Platinum has a high fusing point, does not oxidize, but is not hard enough for long service at high temperature. Messrs. Baker & Co. therefore supply now a special alloy for this purpose.

THE PETERBOROUGH HYDRAULIC POWER CO., of which Senator George A. Cox is president, is building a new power plant on the Otonabee River in the town of Peterborough, Ontario, Canada, which will be equipped with the following apparatus recently purchased from the Westinghouse Electric & Manufacturing Co.: A 1500-kw, 2240-volt alternator, running at 150 revolutions per minute, to be direct-connected to waterwheels; also two 125-volt exciters of 75-kw. capacity each, together with switchboard, consisting of a large generator panel and two exciter panels. This power house, when completed, will be an unusually fine one, and is to furnish power to the Peterborough Mill, of the American Cereal Co., owned by the Quaker Oats Co.; power will be supplied to several other manufacturing plants in the town, and also to the Peterborough Light & Power Co., which does the electric lighting and small power business in Peterborough.

ARTIFICIAL NIAGARA AT ST. LOUIS.—An immense artificial cascade has been determined upon by the authorities of the Louisiana Purchase Exposition as the centerpiece of the semicircular lay-out of the principal buildings. The cascade itself will be divided into three parts; a large middle cascade, with a smaller one at each side, the water flowing directly into the head of the Grand Basin. In all, about 90,000 gallons of water per minute will be supplied at a head of 159 feet, forming the greatest artificial water effect ever attempted.

The water will be taken from the Grand Basin itself and will be raised to the top of the cascade by a pumping station located under Festival Hall. The pumping machinery will consist of three 36-inch single-stage, turbine centrifugal pumps purchased from Henry R. Worthington, of New York city, each driven by a 2000-hp. Westinghouse alternating-current motor. The total horse-power utilized will thus be 6000, making this the largest electric pumping station in the world. The pumps and other pieces of machinery for this plant are now being installed at St. Louis.

PERSONAL.

DR. HANS GOLDSCHMIDT, of Essen-Ruhr, Germany, the inventor of the thermit process, will visit this country in November, and is expected to deliver a lecture in Columbia University.

DR. OSKAR NAGEL has established an office and laboratory, to act as a chemical engineer, consulting chemist and chemical counsel in patent cases, at 90-96 Wall street, New York City.

LIEUT. F. THARALDSEN, who has two large, undeveloped water powers in Norway, of together 200,000 hp. is visiting this country with a view of studying the commercial development of electrochemical industries. His water powers being situated near the sea, he intends to utilize them for electrochemical plants.

DIGEST OF U. S. PATENTS

PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,
National Union Building, Washington, D. C.

DYES AND PIGMENTS. (Continued.)

323,514. August 4, 1885. W. Majert, Grunau, near Berlin, Germany.

Electrolyzes paramido derivatives of primary, secondary and tertiary aromatic amines, and hydrazo compounds of the latter, by dissolving them in water, acidulating, adding a substance which will evolve hydrogen sulphide and electrolyzing. Electrodes, platinum, platinized copper, silver, lead or carbon. May replace hydrogen sulphide by its persulphide, or by sulpho carbonic acid. May replace sulphuric acid by hydrochloric, adding ferrous chloride to neutralize chlorine and chloric and perchloric acids. For example, produces methylene-blue, by dissolving one part of paramido-dimethylaniline in forty parts of water, adding four parts of 66° Baumé sulphuric acid and some sodium sulphide solution, and electrolyzing. Blows air through the electrolyte to remove the residual hydrogen sulphide. The dye is precipitated from the electrolyte by zinc or sodium chloride. The cell is a wooden vessel lined with varnish. A vertical, wooden shaft with radial stirring arms rotates in the vessel. The electrodes are fixed to opposite sides of the vessel, and extend horizontally between the rotating arms, which carry brushes to clean the electrodes. May use a cell with a vertical diaphragm of earthenware, wood or parchment paper, or of earthenware plates set in a wooden framework. Fills one chamber with a sulphuric acid solution of paramido-dimethylaniline, containing sodium sulphide, and the other chamber with a sulphuric acid solution of nitroso-dimethylaniline. Each chamber contains a rotary stirrer, the adjacent arms of one stirrer carrying brushes to clean the anode, and those of the other stirrer, brushes to clean the cathode. This apparatus serves not only to produce methylene-blue, but simultaneously produces from the nitroso-dimethylaniline the paramido-dimethylaniline required for the production of the methylene-blue, the current being reversed through the cell. The anode and cathode compartments may be connected by a bent pipe, instead of using a diaphragm.

477,735. June 28, 1892. J. Blair, Spokane, Wash.

Produces a basic lead sulphate by electrolyzing a solution of sulphuric acid ten parts, sodium or potassium nitrate five parts, and water twelve parts, between vertical lead anodes and carbon cathodes, which line the sides of the cell. Injects steam to heat the electrolyte. The lead is converted into a white powder consisting of sulphate mixed with some nitrate. This powder is washed with a dilute caustic soda solution, to convert the lead nitrate into hydrate. The wash liquor is evaporated and fused with charcoal to reproduce caustic soda.

538,998. May 7, 1895. A. B. Browne, Cambridge, and E. D. Chaplin, Natick, Mass.

To produce lead chromate, first produces a solution of lead nitrate, acetate or chloride in a diaphragm cell with lead electrodes and an electrolyte of an alkali nitrate, acetate or chloride. The caustic alkali overflows from the cathode compartment. Another solution of chrome hydrate is simultaneously prepared by precipitating a solution of chrome alum with caustic alkali, filtering, washing and redissolving in an excess of caustic alkali. The resulting solution is mixed with a solution of sodium chloride and electrolyzed, giving a variable mixture of potassium bichromate and chromate, which is mixed with the lead nitrate, acetate or chloride from the electrolytic cell. The precipitated lead chromate is filtered and washed. The color of the pigment can be varied by varying the relative amounts of the two chromates, which is a function of the time of electrolysis.

554,718. February 18, 1896. Ralph McKenzie, Jersey City, N. J.

Produces lakes or insoluble pigments by dissolving or suspending "the fundamental bases of coloring matters," such as chromic acid, alizarine or cochineal in an electrolyte and passing a current between electrodes of aluminium, tin or other oxidizable metal or alloy. Potential difference, 10 volts. To produce a brilliant red, dissolves aniline in water and electrolyzes with aluminium anodes, producing a "coagulated compound of insoluble hydrated aluminium and aniline."

557,324. March 31, 1896. G. D Burton, Boston, Mass.

Dyes wool, cotton, silk, fabrics, furs and leather in an electrolyte containing dye stuffs and between electrodes of copper, zinc, lead or other metal. Non-conducting screens may be placed in front of each electrode to prevent contact with the material. Some "benefit" is derived from copper electrodes. Cloth to be dyed may be run through the electrolyte. The electric current is said to separate the fibers of the material and cause rapid absorption of the dye. Examples: Water 30 gallons, salt 30 pounds, vitriol 12 ounces and a coloring matter. Specific gravity to be 1.000° to 1.025°. Current, 60 amperes at 500 volts, raising the temperature of the bath to 210° F. For a tank 6 feet by 3 feet by 1 foot deep, uses a current of 100 amperes at 220 volts. May also use a current of 400 amperes at 6 volts. For wool, dissolves 2 pounds of vitriol and 1½ pounds of "Fast Black, 3 B," in 20 gallons of water. Specific gravity, 1.030° to 1.037°. Current 55 to 70 amperes at 220 volts, which raises the electrolyte to the boiling point. To dye hats, blue-black, dissolves 3 ounces of "Hatter's Concentrated Black," 8 ounces of Glauber salt and ¾ ounce of oil of vitriol in 15 gallons of water; for a jet black, adds ½ ounce of "Green B." For an orange color, dissolves 20 ounces of Glauber salt, ¾ ounce of oil of vitriol and 4 ounces of acid-orange in 15 gallons of water. Current, 60 amperes at 220 volts. For a nutria color, dissolves 8 ounces of alizarin-brown in 15 gallons of water. For leather, uses a low current at high voltage.

557,325. March 31, 1896. G. D. Burton, Boston, Mass.

Similar to preceding patent, except both electrodes are of carbon.

557,326. March 31, 1896. G. D. Burton, Boston, Mass.

Apparatus for dyeing and shrinking fabrics. Cell, earthenware lined with porcelain. Porcelain guide rolls in the cell. Anode, carbon; cathode, lead. Fabric may pass twice through the electrolyte. To dye brown and black, first heats the liquor by an electric current, between electrodes of lead, one of which is then replaced by carbon. Sixty amperes at 220 volts heats 20 gallons to the boiling point in ten minutes. Electrolyte for a peacock blue, water 20 gallons, Prussian blue 1½ ounces, citric acid 2 ounces, Glauber salt 1½ pounds, and sulphuric acid 1½ ounces. Specific gravity, 1.125°. Current, 60 to 100 amperes at 120 to 220 volts.

588,883. August 24, 1897. P. G. Salon, Philadelphia, Pa.

To produce litharge, first electrolytically reduces lead ore to sponge. Places crushed galena in a porous cup with a lead cathode, and surrounds the cup with dilute sulphuric acid containing a lead anode. The electrolytic hydrogen converts the lead into a sponge, which is washed, dried and heated, first at a temperature below the melting point of lead and then at a bright red, being thereby converted into litharge.

602,873. April 26, 1898. J. W. Richards and C. W. Roepper, Bethlehem, Pa.

Produces all metallic sulphides except those which are soluble in the electrolyte, by electrolyzing a solution of sodium or other soluble thiosulphate, preferably of 10 per cent strength, with an anode of the metal whose sulphide is desired, and a carbon cathode. Mixed sulphides may be produced by using an alloy anode. The precipitated sulphide is romoved f om the bottom of the cell, filtered, washed, dried and pulverized. For cadmium sulphide, preferably adds 5 per cent of sodium chloride to the electrolyte, and heats it to 75° C. For antimony sulphide, uses a cold solution.

626,330. June 6, 1899. Carl Luckow, Cologne-Deutz, Germany.

Produces lead peroxide, by electrolyzing a 0.3 to 3 per cent aqueous solution of a mixture of sodium, potassium or amonium sulphate, 99.5 per cent, and sodium potassium or amonium chlorate 0.5 per cent, between lead electrodes. Current, 50 amperes at 3 volts. Current density 0.5 amperes per square decimeter. Air is injected during the process.

626,331. June 6, 1899. Carl Luckow, Cologne-Deutz, Germany.

Produces neutral lead chromate by electrolyzing a 0.3 to 3 per cent aqueous solution of sodium, potassium or ammonium chlorate, 80 per cent, and sodium potassium or ammonium chromate, 20 per cent, between electrodes of lead, the anode preferably of soft lead, and the cathode of antimonal lead. Current, 50 amperes at 1.8 volts; density at anode, 0.5 amperes per square decimeter. Electrolyte kept neutral and water and chromic acid continuously added during the electrolysis.

626,547. June 6, 1899. Carl Luckow, Cologne-Deutz, Germany.

Produces copper oxide by electrolyzing a 0.3 to 3 per cent aqueous solution of sodium, potassium or ammonium borate, 95 per cent, and sodium, potassium or ammonium chlorate, 5 per cent, between electrodes of copper. Current, 50 amperes at 2 volts; density, 0.5 amperes per square decimeter. Air is injected during the process.

627,266. June 20, 1899. Carl Luckow, Cologne-Deutz, Germany.

Produces acid lead chromate by electrolyzing a 0.3 to 3 per cent aqueous solution of sodium, potassium or ammonium chlorate, 80 per cent, and sodium, potassium or ammonium chromate, 20 per cent, between electrodes of lead, the anode preferably of soft lead and the cathode of antimonal lead. The electrolyte is kept faintly acid and chromic acid and water are continuously added as consumed. Current, 50 amperes at 1.5 volts; density at anode, 0.5 amperes per square decimeter.

627,267. June 20, 1899. Carl Luckow, Cologne-Deutz, Germany.

Produces basic copper phosphate by electrolyzing a 0.3 to 3 per cent aqueous solution of sodium, potassium or ammonium chlorate, 80 per cent, and sodium, potassium or ammonium phosphate, 20 per cent, between electrodes of copper. Continuously adds phosphoric acid and water, as consumed. Current, 50 amperes, at 2 volts; density at anode, 0.5 amperes per square decimeter.

666,262. January 22, 1901. C. G. Collins, New York.

Produces a composite pigment by electrolyzing an aqueous solution of salt from which barium sulphate may be precipitated, for example the dithionate, and a vegetable or coal tar color, such as an anilin salt capable of electrolytic dissociation. The ions of the anilin salt recombine in the presence of the finely divided barium sulphate precipitate, and the pigment falls to the bottom of the cell. The barium salt and dye may be added as required.

666,302. January 22, 1901. C. G. Collins, New York.

Produces a composite pigment by precipitating finely divided hydrated silica in the presence of a soluble dye, with an insoluble anode. For example, electrolyzes an aqueous solution of sodium silicate and eosin red (potassium tetra-bromo-fluorescein), replenishing the silicate and dye as required.

670,201. March 19, 1901. E. D. Kendall, Brooklyn, N. Y.

Produces precipitated zinc oxide and nitrites by electrolyzing an aqueous nitrate solution, for example, sodium nitrate, between an anode of zinc and a cathode of carbon, copper, iron, tin-plate or lead. May use a tank of wood or one of iron serving as the cathode. Potential difference, 6 volts or less, but preferably more. A tray may rest on the bottom of the tank to receive the zinc oxide.